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APPLIED MECHANICS REVIEWS

VOL. 5, NO. 10 — MARTIN GOLAND *Editor* — OCTOBER 1952

Communications

Concerning **AMR 5, Rev. 1821 (June 1952): J. R. M. Radok, An approximate theory of the oscillating wing in a compressible subsonic flow for low frequencies.**

The approximation of this paper is obtained, in a manner, analogous to the Glauert transformation in the case of the steady problem, by neglecting the wave term in the differential equation for the velocity potential, but it does not neglect the effect of the wake. It should also be noted that Dietze does not obtain exact results since he iterates the induced velocity equation, although for low frequencies his results agree well with those of the exact theory of AMR **5**, Rev. 1475 (May 1952).

J. R. M. Radok, England

Concerning **AMR 5, Rev. 2282 (August 1952):**

The author's name should read Crossley, F. R. Erskine.

Theoretical and Experimental Methods

(See also Revs. 2833, 2863, 2875, 2883, 2887)

2756. **Sorensen, K. E., Graphical solution of hydraulic problems,** *Proc. Amer. Soc. civ. Engrs.* **78,** Separ. no. 116, 17 pp., Feb. 1952.

Graphical method of solution of a first-order differential equation commonly met in hydraulics is outlined. Examples are given of its use in flood-routing through a reservoir; in steady, nonuniform flow in open channels; and in the operation of a simple surge tank. Method is not new, but generalized derivation and illustration of its use should make paper useful to engineers. No indications of accuracy attainable or approximations involved are given. W. B. Baines, Canada

2757. **van der Poel, W. L., A simple electronic digital computer,** *Appl. sci. Res.* (*B*) **2,** 5, 367–400, 1952.

Essential in this computer is that the control registers form part of the arithmetic unit, which results in a very simple method for using subprograms. The arithmetic unit consists of two noncalculating registers and an adding unit for adding three digits together at a time. There is only one instruction register, which consists of a number of flip-flops. The seven possible instructions of this machine have four digits, which are used functionally. Thus no decoder is required. Multiplication and division must be programmed. Examples are given. A small number of short registers, containing one number each, is supplied to serve as working positions. The long registers are so constructed that when the short registers are used, the next instruction just comes out when the former instruction has been executed. The simplifications are achieved at the sacrifice of speed, especially for multiplication and division.

From author's summary by F. A. Willers, Germany

2758. **Boerdijk, A. H., Testing the roundness of shafts** (in Dutch), *Ingenieur* **64,** 6, W.1–W.6, Feb. 1952.

By application of Fourier analysis, the problem of the measurement of faults in the roundness of shafts is investigated. Some known measuring methods supplying information about these faults are criticized. Two new methods are proposed.

From author's summary by M. Kuipers, Holland

2759. **Stiefel, E., On some relaxation methods** (in German), *ZAMP* **3,** 1, 1–33, Jan. 1952.

The general relaxation method of solving n symmetrical ($d_{ik} = d_{ki}$) simultaneous linear equations $\Sigma d_{ik}u_k + l_i = 0$ [1] is developed. $v(v_1, \ldots v_n)$ is a "trial vector" for $u(u_1, \ldots u_n)$; the quadratic $F(v) = \frac{1}{2}\Sigma d_{ik}v_iv_k + \Sigma l_iv_i$ [2] is formed. The residues are given by $r_i = \partial F/\partial v_i$. The solution of [1] is equivalent to finding the minimum of [2].

Correction (Δv) to trial vector is made proportional to an arbitrary "weight vector" (p); $\Delta v_i = \lambda p_i$, where parameter λ is selected to minimize $F(v + \lambda p)$. New residue is orthogonal to p ($\Sigma r_ip_i = 0$). If weight vectors are parallel to coordinate axes, convergence slows down as relaxation proceeds; residues form a "cage."

"Disk-relaxation" is a generalization of block-relaxation; points are relaxed by different amounts to reduce (or eliminate) residuals at all points within disk. Simultaneous application of several weight vectors with a corresponding number of parameters is also treated.

Method of steepest descents is shown to involve corrections proportional to residuals existing at that stage; proportionality constant is again selected to minimize F. Using corrections proportional to existing residuals plus a constant ϵ times the previous correction, the convergence can be accelerated; by proper selection of the constants ϵ, the exact solution can be reached in not more than n steps.

Paper concludes with methods for estimating errors caused by breaking off the process with finite residues.

First part of paper and treatment of steepest descent are similar to G. Temple [*Proc. roy. Soc. Lond.* (*A*) **169,** 476–500, 1939] who also shows extension to nonsymmetrical systems. Over-relaxation is treated very briefly. Illustrative problems are harmonic functions (Laplace equation, Dirichlet's boundary-value problem) for areas with straight boundaries. Special consideration is given to methods suitable for sequence-controlled calculating machines and to the well-known fact that relaxation very quickly smooths the trial function, but it may be a cumbersome task to get rid of the remaining residual distribution.

G. Sved, Australia

2760. **Christopherson, D. G., The relaxation method in stress analysis,** *Brit. J. appl. Phys.* **3,** 3, 65–72, Mar. 1952.

Linear finite-difference equations, introduced in the place of the differential equation $\Delta\phi = \text{const}$ (ϕ stress function in torsional problems, deflection of a membrane), may find a practical solution through the relaxation method. Author gives account of different methods used to accelerate convergence (extrapolation, Fox's difference method, use of triangular mesh) and suggests square mesh with a formula involving eight surrounding points. A simple numerical example is given (torsion of the rectangle).

As regards the fourth-order equation $\Delta^2 w = q/D$ with given w, w_ν on the boundary (w deflection of a plate; Airy's function

when $q = 0$), the simplest fourth-order difference equation would involve thirteen points and convergence would be slow.

Author proposes to solve the equation $\Delta W = q/D$ (write $W = \Delta w$) by the afore-mentioned methods, using as parameters values of W in some points of the boundary. These are determined by equation $\int_A \int W dx dy = \int_c w_\nu ds$ (the same equation which we use for statically indeterminate, single-dimensional structural problems). This equation can be applied repeatedly to areas A, involving the whole or part of the boundary. In a second step, equation $\Delta w = W$ with known w on the boundary is solved.

Example is given for a square plate clamped on all edges, under uniform load.

When "irregular stars" are encountered near the boundary, conformal transformation could be applied to transform the given area into a rectangle, or other simple shape. Examples of this suggestion are not developed. D. Gentiloni-Silverj, Italy

2761. **Berry, V. J., and de Prima, C. R., An iterative method for the solution of eigenvalue problems,** *J. appl. Phys.* **23,** 2, 195–198, Feb. 1952.

The Sturm-Liouville problem is transformed into a sequence of initial value problems which converge to solution of eigenvalue problem. At each step, new λ is obtained as Rayleigh quotient of solution to preceding initial value problem. Example shows rapid convergence. (Reviewer's note: Convergence is quadratic. See S. H. Crandall, *Proc. roy. Soc. Lond.* (A) **207,** 416–423, 1951, where analogous result is proved for matrix eigenvalue problem.) Method requires no orthogonalization. A single higher mode can be obtained without knowledge of the lower modes.

Stephen H. Crandall, USA

2762. **Kampé de Fériet, J., On the spectral analysis of a function stationary on the average** (in French), *Actes Coll. inter. Mécan.* **III,** *Publ. sci. tech. Min. Air, Paris,* no. 251, 317–335, 1951.

A mathematical paper. Consider a truncated function $v(t)$ ($v(t) = 0$, $|t| > T$; $v(t) = u(t)$, $|t| \leq T$) such as is obtained from physical measurements. If, from the physical data, it is probable that $\int_a^b |u(t)|^2 dt$ is finite for any interval (a,b), it is possible to define a correlation function and a spectral function for $v(t)$. In the limit $T \to \infty$ these functions go over into the corresponding functions of $u(t)$, provided $u(t)$ satisfies the three conditions given by Wiener. D. ter Haar, Scotland

2763. **Pennie, A. M., and Belanger, J. Y., A new method for liquid film measurement,** *Canad. J. Technol.* **30,** 2/3, 9–19, Feb./Mar. 1952.

In order to measure $^1/_{10}$–$^1/_{1000}$-in. films of 5% sodium carbonate solutions in water on the inner wall of a copper tube of 0.5-in. diam, an audiofrequency circuit is closed by contact of the film with a sewing needle moved by a micrometer screw. Film thickness vs. flow rate of the sprayed solution is investigated.

Margot Herbeck, Germany

Mechanics (Dynamics, Statics, Kinematics)

(See also Rev. 2818)

2764. **Harrison, M. Sykes, A. O., and Marcotte, P. G., The reciprocity calibration of piezoelectric accelerometers,** *David W. Taylor Mod. Basin Rep.* 811, 14 pp., Mar. 1952.

The direct calibration of accelerometers at frequencies in excess of 1000 cps is difficult due to mechanical problems in generating controlled vibrations. A technique is presented for the calibration of generator-type accelerometers which does not require quantitative control of the shake table. Two such generator-type pickups are used in a series of experiments. There, relative sensitivities are determined by means of an arbitrary input vibration. One pickup is then used as a generator to vibrate the other, and, by adding known masses to the system, it is possible to eliminate the unknowns from the equations so that the quantitative sensitivity of each pickup is determined.

The technique is valuable for piezoelectric transfusers and other generator-type elements. It is not directly applicable to variable reactance pickups which cannot be used in reverse as generators. A useful discussion is presented pertaining to the effect of flexibility of the mounting and other supposedly rigid parts of the accelerometer. C. Desmond Pengelley, USA

2765. **Dzung, L. S., The stability criterion,** "Automatic and manual control," New York, Academic Press, 13–23, 1952, $10.

Author briefly reviews existing stability criteria for discrete linear systems and observes that these are frequently misapplied by ignoring conditions of validity. Not all transfer functions are embraced by these methods. A new criterion is formulated generally, as a pure problem in complex variables. Difficulties are still encountered when there are branch points within the right half plane, but these cases are disposed of by certain supplementary conditions. The method is certain when the analytic form of the characteristic equation is known. In general, this seems to be a good summary of the rationale of the subject.

Robert E. Roberson, USA

2766. **Tao, D. C., and Hall, A. S., Analysis of a symmetrical five-bar linkage,** *Prod. Engng.* **23,** 1, 175–177, 201, 203, 205, Jan. 1952.

Authors analyze a symmetrical five-bar linkage and indicate how it may be used to replace complex combinations of the four-bar and slider-crank linkages. The general motion of the five-bar linkage is defined in terms of the lengths of the links, the speed ratio n of the driven to the driving crank, and the phase angle between these cranks. The effects of these variables on the motion is shown by a series of 12 design charts. The application of these charts is illustrated by a simple design problem. Reviewer believes authors have made a worth-while contribution.

F. L. Singer, USA

2767. **Kraus, R., Valency balance and its application to a straight-line mechanism for measuring instruments** (in German), *Feinwerktech.* **56,** 3, 57–63, Mar. 1952.

Paper deals in its first part with the nature of the valency balance (Werktigkeitsbilanz) which is based on the known fact that the proportions of a linkage and its position are determined by the coordinates of its joints and its coupler point (if the latter is used). By applying the valency balance, it is possible to find the number of assumptions which can be made during the design of a linkage when a prescribed number of requirements are to be fulfilled. In the second part, the valency of different requirements and of different assumptions is discussed and represented by a table. In the third part, several examples demonstrate establishing the valency balance and its application.

Josef Boehm, USA

2768. **Thoren, T. R., Engemann, H. H., and Stoddart,** D. A., **Cam design as related to valve train dynamics,** *SAE Quart. Trans.*, 1-13, Jan. 1952.

Paper is extension of work by W. M. Dudley [title source, Jan. 1948] and offers an advanced method for designing cams of superior performance, particularly for four-stroke cycle automotive

engines. Three steps are involved in developing proper cam contour: (1) A polynomial equation is written for the desired *valve* motion between zero lift and the maximum lift of the form $y = h + C_x x^2 + C_p x^p + C_q x^q + C_r x^r + C_s x^s$, where y is the valve lift corresponding to cam angle x, h the maximum lift, p, q, r, s suitable exponents of even numbers (for instance, 14, 26, 38, 50). This equation and its second derivative (acceleration) are continuous mathematical functions resulting in smooth valve motion. (2) The *cam* lift is computed by means of a second equation for the "equivalent cam," $y_0 = h_r + \rho y + \phi y''$, where h_r is the ramp height, $\rho = (k_0 + k_1)/k_0$ is the factor for the static deflection including linkage flexibility, and ϕ is the factor for dynamic deflection that is caused by the reciprocating masses. (3) After fitting suitable opening and closing ramps, the equivalent cam is converted into the correct cam contour.

In high-speed engines, true valve motion differs much from the geometric motion as obtained at low speed without spring load. Authors, therefore, start with setting up equation for the desired valve motion and convert it afterward into equation for the equivalent cam lift.

With high-speed camera, true valve motion of two "polydyne" cams, and also of the original cams which they replaced, were recorded. The polydyne cams showed much less valve bounce. The recorded valve motion was, however, not quite identical with the mathematically predicted valve motion at the design speed of 3500 rpm. The discrepancy was attributed to differences of valve-train flexibility from valve to valve and to possible nonlinearity of linkage deflection to force. Another cause, reviewer believes, may be resonant valve-spring vibrations, excited by some higher harmonics of the valve motion. These, however, should be small for the types of cams proposed by the authors.

P. H. Schweitzer, USA

Gyroscopics, Governors, Servos

2769. **Aikman, A. R., and Rutherford, C. I., The characteristics of air-operated controllers,** "Automatic and manual control," New York, Academic Press, 175–187, 1952. $10.

Five commercially available types of air-operated controllers are analyzed with view toward setting down their frequency-response characteristics with "effective" integral action time as parameter and with certain specific values given to ratios of other controller parameters. A short qualitative discussion is then given concerning controller adjustments necessary to obtain maximum allowable proportional control factor for a given plant, if plant characteristics are known. Finally, brief remarks are made concerning departures of actual equipment from theoretical characteristics assumed for it in above analysis.

Paper is written in language of industrial process engineer, and the difficulty with which reviewer followed it attests to nonunified state of controls field today. Reasoning used in paper appears to be disconnected and, in some places, incorrect. Thus, in an essential step in the analysis, the expression $\theta + (a + b/bc)\text{-}(p - P)$ appears, and is operated on by a constant, the differential operator, and the integral operator (θ and p are variables), and the statement is made that since $c \gg 1$, $(a + b/bc)(p - P)$ is, in general, negligible compared with θ, and is promptly thrown out of the expression.

Leonard Becker, USA

2770. **Chien, K. L., Hrones, J. A., and Reswick, J. B., On the automatic control of generalized passive systems,** *Trans. ASME* **74,** 2, 175–183, Feb. 1952.

Paper discusses a method for selecting optimum controller settings for process-control systems. Results shown supplement and substantiate those previously described in the literature. Results are approximate, but applicable to many process-control systems; they are not applicable to servomechanisms or other systems involving components exhibiting oscillatory characteristics.

Method involves the approximate representation of a process-control system involving many energy storage elements by an equivalent system having a finite time delay plus a (exponential type) time constant. Object of this approximation is to simplify analytic determination of the response and to permit a more general treatment. Constants of the equivalent system are selected to reasonably match the transient response characteristic of the controlled system under open-loop conditions.

The results, which are presented in dimensionless form, were obtained by analog computer studies. An analog computer study was also made of a seven-capacity system (having seven separate energy storage elements). This was compared with a corresponding study using the approximate representation proposed. Comparison of results was favorable and adequate for engineering purposes, but was based on this type of system only; it is not sufficiently general to prove that there might not be other instances where the proposed approximation method would not provide adequate engineering accuracy.

A number of graphs are provided, giving optimum controller settings for systems so represented. These cover cases where ordinary proportional, proportional-plus-integral, and proportional-plus-integral-plus-derivative controllers are used. The information given will undoubtedly be of value in many process-control problems.

Method proposed appears valid for many engineering purposes. There may be instances when the accuracy is inadequate, but it would be difficult to predict such instances except by specific studies.

Results given would be of particular value when a control designer does not have access to an analog computer. When such a device is available, there would be little point in making such an approximation.

In systems involving many energy storage elements where the validity of the approximation proposed here is subject to question, recourse can always be made to the well-known frequency-response method of analysis with a minimum of computational labor.

Ralph J. Kochenburger, USA

2771. **Howe, W. H., Some recent developments in process control,** "Automatic and manual control," New York, Academic Press, 217–225, 1952. $10.

An account is given of investigations into some fundamental factors affecting the design and operation of automatic process control, particularly of transmission lags in fluid-flow control. Results are given of measurements of time delay in transmission using various lengths of tubing of various sizes. A study of the time delays in a flow test setup and instrument developments that resulted from this work are described.

From author's summary

2772. **Uttley, A. M., and Hammond, P. H., The stabilization of on-off controlled servo-mechanisms,** "Automatic and manual control," New York, Academic Press, 285–299, 1952. $10.

The stability of on-off servomechanisms is considered in terms of power flow. Phase plane methods and diagrams are used for the study of particular problems, and it is shown why damping proportional to the square of velocity is theoretically best. Practical servos are described that have been constructed employing velocity-squared damping by electrical and mechanical methods. There has been good agreement between theory and practice.

From authors' summary by Andrew Vazsonyi, USA

Vibrations, Balancing

2773. Yu, A.-t., Vibration damping of stranded cable, *Proc. Soc. exp. Stress Anal.* **9, 2, 141–158, 1952.**

Paper treats damping capacity of three commercial stranded cables, both theoretically and experimentally. Two of the cables were $^3/_8$-in. diam, 7 strand; the other was 0.297-in. diam, 3 strand. Lay lengths varied from 5.0 to 8.4 in. Author concludes that the source of internal damping consists essentially of the interstrand dry friction. Without tension on the cable, the damping capacity is a linear function of amplitude, and the frictional resisting moment against bending increases with amplitude below a small "critical amplitude" but tends to assume a constant value above this amplitude.

Factors that influence the internal damping are: (1) Damping capacity is reduced by an increase in lay length; (2) damping capacity is higher for cables having greater number of constituent wires; (3) prestressing of stranded cables below the yield point has no effect on damping capacity, while prestressing over the yield point reduces the damping capacity; (4) "preformed" cables possess less damping capacity than the nonpreformed type. Richard H. Kemp, USA

2774. Dalley, J. W., and Ripperger, E. A., Experimental values of natural frequencies for skew and rectangular cantilever plates, *Proc. Soc. exp. Stress Anal.* **9, 2, 51–66, 1952.**

The natural frequencies of the first five modes of thin skew cantilever plates, representing idealized missile fins, with 0, 15, 30, 45, and 60° angles of skew and of rectangular plates with length-to-breadth ratios $^1/_2$, 1, 2 and 5 were experimentally determined. Node patterns associated with the various frequencies had been photographed. Results are shown in diagram and tables. Test equipment and technique for measuring plate frequencies are described. Accuracy of results is discussed and necessity of sufficiently accurate measuring of the physical constants of the plate material is emphasized.

Pavel Kohn, Czechoslovakia

2775. Temple, G., The accuracy of Rayleigh's method of calculating the natural frequencies of vibrating systems, *Proc. roy. Soc. Lond.* **(A) 211, 1105, 204–224, Feb. 1952.**

Exact treatment is given of Kato's theorem, extended to systems incorporating elastic and inertial coupling. Author shows that the upper and lower bounds of the fundamental or any overtone eigenvalue of a generalized Lagrangian system can be simply determined.

Reviewer believes this clearly written paper is of comparable value to the author's well-known discussion of the method of steepest descents applied to the relaxation theory. An understanding of these new principles is a desirable addition to vibration theory. James B. Duke, USA

2776. Ayre, R. S., Transient vibration of linear multi-degree-of-freedom systems by the phase-plane method, *J. Franklin Inst.* **253, 2, 153–166, Feb. 1952.**

Paper shows the application of phase-plane graphical methods to transient forced vibrations of undamped, linear systems having more than one degree of freedom. Lumped parameter as well as distributed parameter systems are included. An introductory application to a single-degree-of-freedom system is followed by examples relating (1) to the two-degree-of-freedom two-mass system, (2) to the two-degree-of-freedom single-mass system with inertia coupling, and (3) to a simply supported uniform beam. The essential feature is the independent application of the phase-plane method to each normal coordinate of a system.

The use of the phase-plane method must save a considerable amount of time. The examples given are very instructive, and the paper may safely be recommended to those concerned with numerical calculations. Sven T. A. Ödman, Sweden

Wave Motion, Impact

(See also Revs. 2872, 2968)

2777. O'Brien, M. P., and Morison, J. R., The forces exerted by waves on objects, *Trans. Amer. geophys. Un.* **33, 1, 32–38, Feb. 1952.**

Two experiments were made to determine the force exerted by surface waves on a submerged spherical object, of diameter D, near the bottom, in order to elucidate sand transport mechanism. The diameter was much less than the wave length. In the first experiment, the sphere was held at an unspecified small distance above the bottom; the horizontal force was measured at four instants in every cycle, and an attempt was made to analyze the force into drag and inertia components

$$F = \pm \tfrac{1}{2}\rho C_D(\pi D^2/4)u^2 + \rho C_M(\pi D^3/6)\frac{\partial u}{\partial t}$$

where u is the undisturbed horizontal velocity, and C_D, C_M are nondimensional drag and inertia coefficients. The Reynolds number Du/ν (definition Eq. 11 is misprinted) is in the range $10^3 - 10^4$ and C_D was expected to depend on it, while C_M was not. These expectations were roughly borne out. In the second experiment, sphere rested on a tee on the bottom, and force needed to dislodge sphere was measured.

Reviewer's comments: Measurements are rather rough; e.g., runs 7 and 7A, under identical conditions, give values of C_M differing by 20%. Authors compare their C_D with values for steady flow known to them, but give no reference for the latter, which differ from well-known values for sphere in free space. Reviewer knows no measurements of C_D for sphere near plane boundary. Reviewer would like to draw attention to Jeffreys [*Proc. Camb. phil. Soc.* 25, p. 272, 1929] where importance of (vertical) lift force is stressed; and to the fundamental work on sand transport in water by Bagnold [*Proc. roy. Soc. Lond.* (A) **187**, p. 1, 1947].

F. Ursell, England

Elasticity Theory

(See also Revs. 2791, 2797, 2860)

2778. Teissier du Cros, F., Singular points of a two-dimensional elastic equilibrium field (in French), *Ann. Ponts Chauss.* **122, 1, 1–25, Jan.-Feb. 1952.**

Starting from the equations of equilibrium in terms of the rotation and dilatation, author derives another representation of the general displacement and stress field for the case of plane strain or generalized plane stress via two analytic functions of a complex variable. The present form is a symmetric variant of that given by Love, and is applied to a formal classification of point singularities. No reference is made to the extensive and systematic treatment of the plane problem by means of the complex function theory in the more recent Russian and English literature.

E. Sternberg, USA

2779. Csonka, P., A solution system of the fundamental equations of the theory of elasticity (in German), *Acta Techn. Hung., Budapest* **2, 2/4, 487–490, 1952.**

After writing the equation of motion of elastic body as $\nabla^2\xi + (m/m - 2)\partial e/\partial t = 0$ (where (ξ, η, ζ) is the displacement vector,

$\epsilon = \operatorname{div}(\xi, \eta, \zeta)$, and m is the Poisson number), author proposes a solution of the type

$$\xi = \sum_{-\infty}^{\infty}(-1)^j[-jma^{\mathrm{I}} + b^{\mathrm{I}} - 2ma^{\mathrm{I}} + 2a^{\mathrm{I}}]F_{2j}{}^{\mathrm{I}}(y,z)\cdot H_{2j-1}{}^{\mathrm{I}}(x)$$
$$+ \sum(-1)^j[jma^{\mathrm{II}} + b^{\mathrm{II}}](F_{2j}{}^{\mathrm{II}}(z,x))_x H_{2j}{}^{\mathrm{II}}(y)$$
$$+ \sum(-1)^j[jma^{\mathrm{III}} + b^{\mathrm{III}}](F_{2j}{}^{\mathrm{III}}(x,y))_x H_{2j}{}^{\mathrm{III}}(z)$$
$$+ c^{\mathrm{I}} + \omega^{\mathrm{II}}z - \omega^{\mathrm{III}}y)$$

Here a^N, b^N, c^N, $\omega^N (N = \mathrm{I}, \mathrm{II}, \mathrm{III})$ are arbitrary constants, and F^N, H^N are related by the next three sets of expressions.

$$(F_{2j}{}^{\mathrm{I}})yy + (F_{2j}{}^{\mathrm{I}})zz = F_{2j+2}{}^{\mathrm{I}},\ (H_{j+1}{}^{\mathrm{I}})_x = H_j{}^{\mathrm{I}}$$

(Other two sets of equations are obtained by cyclic change $x \to y \to z$ and $\mathrm{I} \to \mathrm{II} \to \mathrm{III}$.)

Author proves that the above expressions can satisfy the fundamental equation, and asserts that they are convenient for the theory of plates, but no application is shown. Description is too short to know sufficiently the practical convenience.

Yasuo Satô, Japan

2780. **Melan, E., Thermal stresses in a disk caused by a wandering heat source** (in German), *Ing.-Arch* **20**, 1, 46–48, 1952.

Uniform motion of a point source of heat is assumed to be rectilinear and to have continued long enough to permit establishment of a quasi-stationary temperature field, moving along with source. From known solution for this temperature field, the corresponding quasi-stationary field of thermal stresses induced in the thin disk concerned is deduced by a method previously developed by author. Author aims at judging thermal stresses induced during welding together of two plates along edges. Reviewer holds results are at least equally important for deducing, by integration, the thermal stresses induced by the band-shaped sources of (frictional) heat that are constituted by the areas of contact between cylindrical surfaces rubbing on each other; certain types of gear-pitting might thus be explained. H. Blok, Holland

2781. **Gassmann, F., Elastic waves through a packing of spheres,** *Geophysics* **16**, 4, 673–685, Oct. 1951.

Based on a theory of porous solids previously developed by the author [AMR **5**, Rev. 1654], the elasticity of a hexagonal close packing of equal spheres is treated. The packing is anisotropic and, because of the weight of the spheres, also inhomogeneous. The velocities of propagation of elastic waves have been calculated for evacuated interspaces and for interspaces filled with a liquid or gas. In the case of evacuated or air-filled interspaces, the wave rays and travel times have been computed. The packing which has been treated may be of use as a model for a dry or wet loose material, such as gravel or sand. Though the model is very much simplified, the results obtained show such typical effects as anisotropy, inhomogeneity, and a 90° angle of emergence.

From author's summary by W. C. Johnson, Jr., USA

Experimental Stress Analysis

2782. **Franz, W. F., A three-dimensional photoelastic stress analysis of a threaded drill pipe joint,** *Proc. Soc. exp. Stress Anal.* 9, 2, 185–194, 1952.

The photoelastic analysis was performed on full-scale Fosterite models of a $2^5/_8$-in. OD American Petroleum Institute standard internal upset pipe joint, for drilling oil wells. Two specimens were tested using the fixation or "stress freezing" technique, followed by examination of stress patterns from longitudinal slices. The second model was made to simulate more closely the steel prototype by making coupling wall oversize and therefore increasing longitudinal stiffness of this part. Results from a slice $^1/_{16}$ in. thick showed a maximum stress concentration factor at the root of the last engaged thread of 4.2 to 4.6 with a possibility of a maximum value of 5.0. These agree rather closely with fatigue tests made on polished-steel test specimens. Careful experimental techniques produced excellent fringe photographs. Reviewer feels that photoelastic results may be slightly high, since the maximum stresses observed in the fillets were somewhat above the presently published values for the optical proportional limit of Fosterite. E. O. Stitz, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Rev. 2758)

2783. **Bornscheuer, F. W., Systematic representation of the bending and twisting process with special consideration of torsion with warping forces** (in German), *Stahlbau* **21**, 1, 1–9, Jan. 1952.

Author considers bending and torsion of straight prismatic rods with open or closed thin-walled cross sections according to engineering theory. Calculation of stresses and deformations is simplified by introduction of "normalized" coordinates through center of area of cross section and in directions of its principal axes. Systematic and schematic approach is designed for helping engineers in problems of torsion with warping.

W. Freiberger, England

2784. **Heyman, J., Elasto-plastic stresses in transversally-loaded beams,** *Engineering* **173**, 4495, 4496; 359–361, 389–390; Mar. 1952.

Author gives numerical results for a uniform beam under two loading systems. Method is that of AMR **4**, Rev. 203.

D. N. de G. Allen, England

2785. **Jäger, K., The influence of the distribution of reinforcement on the stresses in statically indeterminate reinforced concrete beams** (in German), *Z. Öst. Ing.-Arch.-Ver.* **97**, 1/2, 3/4; 8–10, 26–31; Jan., Feb. 1952.

In the first article, theoretical argument is developed; in the second, it is applied to several simple examples. Author uses a theory of design of reinforced-concrete beams at working load, based on a parabolic distribution of compressive stress in concrete, instead of usual straight line. Using this theory, author shows that stiffness of section of beams is dependent on reinforcement in that length, and, therefore, moments in indeterminate structures may vary from those calculated, assuming uniform stiffness throughout each member. It is shown that this may cause the actual stresses under working level to be from 13% greater to 19% lower than those for which the member is designed.

Examples treated are (1) beam built in at one end carrying a distributed load, (2) beam built in at one end carrying a concentrated load at the center, (3 and 4) the same loads on beams built in at both ends, (5) beam continuous over two spans with different distributed loads on each span. Frank A. Blakey, Australia

2786. **Sonntag, G., Transition from the state of plane stress to state of plane deformation in a broad curved beam** (in German), *ZAMM* **31**, 11/12, 344–348, Nov./Dec. 1951.

The stresses, deflections, moments, and reactions of a plate of finite length between two supports and infinite width are well known at any point of the plate. They are also known for the case of a plate with the same length but negligible width, whereby the plate becomes a beam. However, for plates of finite length

between the supports and a width less than infinite but more than zero, the above data are known exactly only at the center line which cuts the width into two halves. Author developed a general and exact solution for the distribution of deflections and moments at any point across the full width of a plate, from the center line to the free unsupported edges.

Reviewer, after careful search, agrees with author that this analysis has not been published previously. Author applies his solution to the case of a broad beam with hinged ends subjected to a uniform load and also to a broad beam with hinged ends stressed only by end moments. F. B. Schneider, USA

2787. **Sykes, A. O., The use of helical springs as noise isolation mounts,** *David W. Taylor Mod. Basin Rep.* 818, 10 pp., 2 tables, 11 figs., Feb. 1952.

Paper presents results of an experimental study of five copper-manganese and one steel spring used as noise-isolation mounts. Extensive recordings are presented of transmissibility vs. frequency for each of the above springs, together with a summary of a theoretical analysis. Author concludes that helical springs are usually inferior to either rubber-shear or compression mounts from the point of view of noise isolation.

Robert E. Heninger, USA

2788. **Andrews, L. C., Piping flexibility analysis by model test,** *Trans. ASME* **74,** 1, 123–131, Jan. 1952.

Theoretical stress analysis of piping resolves itself into solution of a large number of simultaneous equations. Paper describes valuable test apparatus whereby this may be avoided. Forces and moments are applied to required points by means of three-dimensional crosses. Six electrical strain gages are attached to the arms of each cross, and a compact unit consisting of six Wheatstone bridges for the determination of the applied forces and moments is described. Sample experimental investigations are given and thoroughly discussed. H. D. Conway, USA

2789. **Stüssi, F., The thin-walled slender steel bar of box-shaped cross section** (in German), *Inter. Assn. Bridge struct. Engng.*, Repr. from *Publications* **11,** 375–389, 1951.

The loading of prismatic slender thin-walled bars with closed cross section is subdivided into a bending without torsion and a torsion without bending; the assumption is made that the shape of the cross sections remains unchanged during the deformation, which in the case of bending leads to the known condition that plane cross sections remain plane. The induced shear flux is determined as a redundant magnitude according to the known rules for calculating statically indeterminate systems.

H. Schlechtweg, Germany

2790. **Stoeckly, E. E., and Macke, H. J., Effect of taper on screw-thread load distribution,** *Trans. ASME* **74,** 1, 103–112, Jan. 1952.

The load distribution on the threads of bolts and nuts, made in the conventional constant-pitch manner and with tapered threads, was determined experimentally and theoretically. The results indicate that substantial improvement, in the order of 2 to 1, in thread load distribution can be made by tapering the thread of either the bolt or nut properly. Material improvement in bolting strength is obtained in applications that normally are conducive to little plastic flow and thus liable to result in brittle fractures, such as are encountered with dynamic loads or static loads at elevated temperatures. Ten years of operational experience on high-temperature high-pressure turbine bolting is cited to substantiate indicated improvements.

From authors' summary by W. J. Carter, USA

Plates, Disks, Shells, Membranes

(See also Revs. 2788, 2798, 2816, 2817)

2791. **Gedizli, H. S., Bending, by lateral loads, of orthotropic rectangular plates, simply supported along two edges** (in French), *Publ. inter. Assn. Bridge struct. Engng.* **11,** 111–128, 1951.

Author considers the equation $D_x w_{xxxx} + 2Hw_{xxyy} + D_y w_{yyyy} = p\,(x,y)$ of the orthotropic plate, simply supported at $y = 0, b$, free at $x = -a_1, +a_2$, when p is a uniform line load: $p = p\,(0,y) = \text{const}$, for $v - d < y < v + d$, and zero elsewhere (v and d, as well as location of ordinate $x = 0$, are arbitrary). Author expands p into a series in $\sin n\pi y/b$, and considers it as a boundary load, along edge $x = 0$, shared by a left ($x < 0$) plate and a right ($x > 0$) plate. The problem thus reduces to solution of the homogeneous orthotropic plate equation with the boundary conditions, w, w_x, M_x are continuous across $x = 0$, the shear force jumps by p, and the boundary conditions along the other edges are conventional. Solution is obtained by assuming $w_{\text{left}} = \Sigma w_n(x) \sin \beta_n y$, $w_{\text{right}} =$ similar, and adjusting the arbitrary constants involved to the boundary conditions. (The w_n are of the form $A_n \cosh \delta_n x + B_n \sinh \delta_n x + C_n \cosh \gamma_n x + D_n \sinh \gamma_n x$ for $H^2 - D_x D_y > 0$, and of a somewhat more complicated form for $H^2 - D_x D_y < 0$.) Gabriel Horvay, USA

2792. **Favre, H., and Chabloz, E., Study of bent circular plates of linearly variable thickness** (in French) *Bull. tech. Suisse Rom.* **78,** 1, 1–8, Jan. 1952.

Authors derive expressions for the deflection and stresses for circular plates with linearly varying thickness, with edges clamped or simply supported, and acted upon by a concentrated force applied at the center. Making the usual assumptions, like earlier investigators, authors skillfully choose convenient parameters and establish a differential equation of the deflection surface of the plate. Solution of this equation yields, in a general manner, expressions for the deflection, moments, and stresses. They are applicable to a plate whose thickness reduces linearly either from the center to the edges or in the opposite direction. Further, they may be used equally well in the case of a plate whose middle surface is plane and both faces are conical surfaces of revolution, or when the middle surface has a slight initial curvature and one face is plane while the other is a conical surface of revolution.

Several diagrams represent deflections, moments, and stresses as functions of the diameter of plate for various load ratios.

Wilhelm Ornstein, USA

2793. **Oberti, G., and Moravia, G., Measurement and calculation of stresses in a flywheel** (in Italian), *Metallurgia ital.* 44, 2, 78–82, Feb. 1952.

Disk stresses were measured by means of strain gages fixed at a number of points on the disk surface. In order to minimize slip-ring resistances, a circuit with rotating bridge was adopted.

The theoretical stress calculation is based on Grammel's method supplemented by photoelastic tests for the center part of the disk with relatively complicated shape. Comparison of experimental and theoretical values shows that measured stresses are slightly higher than those calculated. E. Haenni, Switzerland

2794. **Zenova, E. F., and Novozhilov, V. V., Symmetric deformation of toroid-shaped shells** (in Russian), *Prikl. Mat. Mekh.* **15,** 5, 521–530, Sept./Oct. 1951.

Problems of elastic equilibrium of symmetrically loaded shells of revolution can be reduced to a differential equation of the second order for the complex resultant $\tilde{T}$ [Novozhilov, V. V., "Theory of thin shells," Moscow, 1947] by which all displace-

ments, stress resultants, and couples can be expressed. Applying Blumenthal's transformation to the corresponding homogeneous equation of a toroid shell and using simple approximations for the coefficients, general solution is given with Hankel functions of the first and second kind, which is very suitable for numerical computation throughout the whole interval. Particular solution of the inhomogeneous equation of the shell under uniform pressure is given in the form of Fourier series; its coefficients can be expressed as continued fractions and converge fairly well.

Anton Kuhelj, Yugoslavia

2795. **Niordson, F. I. N., Transmission of shock waves in thin-walled cylindrical tubes,** *Trans. roy. Inst. Technol. Stockholm* 57, 22 pp., 1952.

Author treats problem of a plane shock wave transmitted in a medium inside a thin-walled circular cylinder and the interaction between the shock wave and the walls of cylinder. The expressions for energy and the deformation of the tube due to the passage of the shock are presented. It is shown that the deformation becomes considerable when the velocity of the shock wave is close to but above a certain critical velocity. The case of a shock wave moving in a tube of constant inner diameter but with an abrupt change in a wall thickness is also treated.

Harry H. Hilton, USA

2796. **Conte, S. D., The circular plate with eccentric hole,** *Quart. appl. Math.* 9, 4, 435–440, Jan. 1952.

This plate has a load acting normal to the upper surface. After introducing bipolar coordinates, the boundary conditions are simplified and the plate equation becomes a linear partial differential equation with constant coefficients. For clamped or simply supported edges, solutions are obtained in series of biharmonic functions. For some forms of the load function, a solution can be found in closed form.

M. Botman, Holland

2797. **Parkus, H., Weld stresses in a rotationally symmetric** disk (in German), Alfons Leon Gedenkschrift, Verlag Allg. Bau-Z., Wien, 65–67, 1952.

Author studies thermal stresses in an infinitely large plate when, at time $t = 0$, a circular hole is welded. Author assumes the heat transferred to the disk to be known and, by this, temperature is deduced in every point of it. Determination of elastic and plastic stresses in the disk follows. It must be pointed out that result is approximate, because stresses are determined assuming a stepwise distribution of temperature along the radius.

Giulio Supino, Italy

Buckling Problems

2798. **Johnson, E. E., and Goldhammer, B. F., A determination of the critical load of a column or stiffened panel in compression by the vibration method,** *David W. Taylor Mod. Basin Rep.* 800, 15 pp., Feb. 1952.

Application of the vibration technique to predict the primary buckling of a plate-stiffener system. The fundamental frequency of the stiffened plate was determined at various axial loads, and extrapolation to zero frequency yielded the critical buckling load for the system. Authors' use of the method of least squares for extrapolation must be employed with caution. It can only yield meaningful results if prior verification has been made that the experimental points do, in fact, approximately follow the theoretical relationship.

Other investigators [*J. appl. Mech.* 19, 2, 195–204, June 1952, and AMR 5, Rev. 653] have previously shown that the vibration method does not yield useful results when applied to thin plates or to stiffened plates where local buckling can occur between stiffeners. This paper clearly verifies the practical applicability of the method to a plate-stiffener system where local instability does not occur.

Harold Lurie, USA

2799. **Goodier, J. N., and Plass, H. J., Energy theorems and critical load approximations in the general theory of elastic stability,** *Quart. appl. Math.* 9, 4, 371–380, Jan. 1952.

Authors first show by Wirtinger's inequality that the buckled form (sinusoidal under the true critical load) of the ordinary uniform pinned-end column is itself stable with respect to disturbances which project it into nonsinusoidal forms. It is neutral with respect to sinusoidal disturbances. Also, the approximate critical load calculated from the potential energy equation for the column by assuming an approximate nonsinusoidal deflection curve will be higher than the true critical load. On the basis of results for the ordinary pinned-end column, authors consider the general stability problem in detail. "If we are given that the buckled form is itself not unstable, this datum establishes the inequality, and we can then use it to prove that the energy approximations to the critical loads will be too high." From the general equations of equilibrium in elasticity theory, the generalized energy relation in terms of the critical stresses and the actual buckling displacements is derived. This result is used to define an inequality equivalent to that for the ordinary column.

B. E. Gatewood, USA

2800. **Sri Ram, G., and Rao, G. V. R., Buckling of an N-section column,** *J. aero. Sci.* 19, 1, 66–67, Jan. 1952.

The Euler buckling of a stepped column with N sections is solved by differential equations. By neglecting certain terms in the determinantal equation, the authors determine close lower bounds for the critical loads.

M. G. Salvadori, USA

2801. **Mansfield, E. H., Elastic instability of a swept panel,** *Aircr. Engng.* 24, 276, 48–49, Feb. 1952.

Author approximates buckling load (parallel to stringers) of a swept-wing panel assumed clamped on its four edges. Upper and lower bounds are found by considering rectangular panels larger than and smaller than the skew panel, assuming only one buckle and using known results for rectangular panels. References to these known results are not given. This method is used only in cases of fairly long and fairly short panels. In case of intermediate panel, author uses Rayleigh-Ritz method with an assumed function closely describing experimentally observed shape of buckle. Unfortunately, only a few results are given in the paper.

H. J. Plass, USA

2802. **Wang, C.-T., and Rao, G. V. R., A study of an analogous model giving the nonlinear characteristics in the buckling theory of sandwich cylinders,** *J. aero. Sci.* 19, 2, 93–100, Feb. 1952.

In previous papers, authors investigated the axial compressive buckling loads of sandwich cylinders by means of small-deflection sandwich-shell theory. They found that their theoretical results for cylinders with weak cores agreed well with experiment. This good agreement between small-deflection theory and experiment is not found for homogeneous cylinders, and this discrepancy is explained by the results of the nonlinear large-deflection theory—i.e., with increasing distortion of the cylinder, the load drops rapidly and reaches a minimum well below the classical buckling load.

To explain the apparent difference between homogeneous cylinders and sandwich cylinders with weak cores, authors have

investigated the buckling of a sandwich column with nonlinear lateral supports. This model has been shown by von Kármán, Dunn, and Tsien ["The influence of curvature on the buckling characteristics of structures," title source, **7**, 7, p. 276, May 1940] to reproduce the typical features of the buckling of cylindrical shells. The results of the investigation indicate that while load decreases from the classical buckling load as deformation of the sandwich cylinder takes place, the difference between the buckling load and the minimum load decreases as the shear stiffness of the core decreases, which phenomenon explains the good agreement between small-deflection theory and experiment for sandwich cylinders with weak cores. Paul Seide, USA

2803. **Cox, H. L., Note on the Southwell method for estimating critical loads,** *Aero. Res. Counc. Lond. Rep. Mem.* 2696, 8 pp., Feb. 1947, published 1951.

Author discusses the effects of variation of stress distribution, elastic failure of the material, and variation of critical stresses on the mentioned method. This analysis supplements previous discussion by Donnell and shows that for most practical cases of these types of variations a fair approximation to the true critical value should be expected. George A. Zizicas, USA

2804. **Conway, H. D., Graphical analysis of axially end-loaded beams,** *Mach. Design* **23**, 1, 137–188, Jan. 1951.

Paper explains the graphical analysis invented by J. Ratzersdorfer [*Z. Flugtechn. Motorluftsch.* **11**, p 102, 1920] and H. B. Howard ["The stresses in aeroplane structures," Pitman, London, 1933, pp. 32 and 72]. It is clearly written but does not seem to contain any original addition. Reviewer stresses that a useful modification of the method, not mentioned by the author, was published five years ago in the United States [V. Rojansky and R. A. Beth, *J. appl. Mech.* **14**, 3, 202–208, 1947].

Ch. Massonnet, Belgium

2805. **Kirste, L., and Müller-Magyari, F., On the buckling of free, thin-walled profile flanges under bending stress** (in German), Alfons Leon Gedenkschrift, Verlag Allg. Bau-Z., Wien, 49–52, 1952.

Lateral buckling of individual flanges of beams during bending is considered mostly for flanges located on the compression side of the cross section. Author illustrates cases where buckling takes place with flanges located on the tension side. Using the method of variation, author develops an expression leading to the critical bending moment for the case of a thin-walled tensile flange being hinged to the compressive part of the cross section at the neutral axis and laterally supported at both ends. The possibility of equilibrium after buckling is discussed.

S. E. Kindem, Norway

2806. **Gerard, G., Compressive and torsional instability of sandwich cylinders,** Symp. Struct. Sandwich Constr., *ASTM spec. tech. Publ.* 118, 56–69, 1952. $2.

Buckling stresses for a circular sandwich cylinder having an isotropic core are obtained for two types of end-loading: (1) A uniform axial compression load acting on the face plates; (2) a torque acting at the ends of the face plates. Linear theory is employed. The faces are assumed to be membranes, and the core carries only the transverse shear stresses. Present paper gives an analysis for over-all buckling. Some discussion is also offered of wrinkling which is the type of buckling observed for relatively thick cylinders. The formulas for the buckling stresses are simplified considerably by a further assumption that the cylinder is thin. It is of interest to note that, under similar assumptions, D. M. A. Leggett and H. G. Hopkins [*Aero. Res. Counc. Rep. Mem.* no. 2262, 1942] obtained the buckling stress. The resulting formulas in the present paper are simpler, however, and may be of interest to the practical engineer.

While the author, in his discussion of other papers, questions the applicability of the linear theory to the study of the wrinkling phenomena, his own theory and the formulas he recommends for the case of wrinkling are also based on the linear theory.

Cemal Eringen, USA

2807. **Menyhárd, I., Design of struts on the basis of prescribed initial eccentricities** (in German), *Acta Techn. Hung., Budapest* **2**, 2/4, 431–448, 1952.

Paper explains new Hungarian specifications. First part discusses known theoretical concepts (Perry formula, Jezek formula), and remainder of paper deals with practical aspects, viz., design values of constants in formulas, simplified design formulas, and design procedures (with numerical example).

F. J. Plantema, Holland

2808. **Cox, H. L., and Bailey, D. L. R., Buckling of struts: two cases giving abnormally low loads,** *Engineering* **173**, 4494, p. 340, Mar. 1952.

For a simple Euler strut, for which the Euler load is $k(\pi^2 EI/L^2)$, the magnitude of k varies between $^1/_4$ and 4, depending on the end conditions. Author discusses briefly two simple strut cases in which, because of slightly unusual end conditions, k can take on much smaller values than those just mentioned; values possible are $k = 0.075$, and $0 \leq k \leq 0.14$. F. S. Shaw, USA

2809. **Pride, R. A., Plastic buckling of a simply supported plate in compression,** *J. aero. Sci.* **19**, 1, 69–70, Jan. 1952.

Author describes new tests with annealed square tubes of 14 S-O aluminum alloy, providing region where discrepancy between deformation and flow-type buckling theories is very large. Small scatter of test results and stress-deflection diagrams show that influence of initial imperfections was negligible. Tests confirm reviewer's theory of plastic buckling of plates [*Proc. k. Ned. Akad. Wet.* **41**, 7, 731–743, 1938; AMR **1**, Revs. 613, 1206; **3**, 1925] as also used by NACA with simplifying assumption that Poisson's ratio is one half in elastic as well as plastic region [AMR **1**, Revs. 805, 1331] and which is based on deformation or finite theory of plasticity. It has been contended [AMR **1**, Rev. 1329; **4**, Revs. 1097, 1100] and denied by reviewer [loc. cit. 1938; AMR **4**, Revs., 1098, 1991] that flow-type buckling theory should be used. P. P. Bijlaard, USA

Joints and Joining Methods

(See also Rev. 2780)

2810. **Thomas, R. D., Jr., Welding of high-alloy castings,** *Weld. Res. Suppl.* **17**, 1, 27s–32s, Jan. 1952.

A cast test plate containing a slotted groove was employed for evaluating the variables in welding 15 Cr-35 Ni (Type HT) castings. Cracks in 1-in. thick welds in this material were encountered in each of 24 test plates welded by four foundries using a variety of techniques and electrodes. Tensile tests on a few transverse-weld specimens gave ultimate strengths of 40,000 to 45,000 psi at 1400 F, and 17,000 to 21,000 psi at 1800 F, with fractures occurring sometimes in the weld and sometimes in the base metal. The groove design of the cast plate is considered very satisfactory for evaluating the welding variables in a test program, or for qualifying welding procedures and determining the weldability of materials.

From author's summary by Frederick J. Winsor, USA

2811. **Bailey, G. L. J., and Watkins, H. C., The flow of liquid metals on solid metal surfaces and its relation to soldering, brazing, and hot-dip coating,** *J. Inst. Metals* **80,** 57–76, 1951–1952.

Earlier investigations of soldering performance are reviewed, and, after a theoretical discussion of factors expected to control the flow of liquids on solid surfaces, experimental investigations of the behavior of several liquid metals and alloys in contact with various solid metals are described. Most of the work was carried out using hydrogen as a flux, but a few experiments with liquid fluxes are also described.

It is found that the contact angle between solid and liquid surfaces of the metals examined is not, in general, zero. Its true value in given circumstances is obscured by the effects of roughness of the solid surface, which cannot be allowed for. Roughness effects could also account for the fact that the contact angle against a surface over which liquid has receded is generally lower than that against a surface over which a liquid has advanced. The development of the particularly low contact angles, which are formed against copper by tin-lead alloys with compositions in the range preferred for practical soldering, appears to be preceded by the formation of an alloy layer in the surface of the copper over which the liquid metal spreads. The alloy layer may be formed relatively slowly by diffusion through the surface layers of the copper from the bulk of the liquid metal, or it may be formed relatively quickly as a result of transfer of metal ions through suitable liquid fluxes. The production of particularly low contact angles between lead and iron or copper and between tin and copper, through very small additions to the lead or tin, is described.

From authors' summary by Frederick J. Winsor, USA

Structures

(See also Revs. 2785, 2801, 2802, 2806, 2843, 2847)

2812. **Symonds, P. S., discussion by, Welded continuous frames: Plastic design and the deformation of structures,** *Weld. Res. Suppl.* **17,** 1, 33s–36s, Jan. 1952.

Author proposes a simplified method for computing deflections at ultimate load for indeterminate frames of low-carbon structural steel (material which yields without strain hardening). Comparison is made with method previously proposed by Yang, et al. [AMR **4**, Rev. 4134]. Numerical examples show comparison with more accurate analyses and with test results on small model frames tested by Baker and Heyman [*Struct. Engr.* **28,** p. 137, 1950]. Although method is somewhat unconservative it should prove to be useful for many practical applications.

Stanley U. Benscoter, USA

2813. **Palotás, L., Calculation of space frame structures by the method of moment equalization** (in German), *Acta Techn. Hung., Budapest* **2,** 2/4, 199–283, 1952.

In chapters A, B, and C, paper gives a rigorous method generalizing the Cross procedure for the case of space structures. Chapters D and E are devoted to the particular case of centrally symmetrical frame structures, e.g., basements of water and cooling towers. It is shown first that, for this category, the general method simplifies itself appreciably. Besides, three different approximate procedures are developed for the symmetry case; they apply to vertical as well as wind loads. The approximate techniques provide practical as well as sufficiently accurate tools for daily use in the drawing office. Ch. Massonnet, Belgium

2814. **Bažant, Zd., Spatial supporting frames** (in French), *Publ. inter. Assn. Bridge struct. Engng.* **11,** 1–16, 1951.

The bars in a stiff-jointed frame are stressed with any desired load by normal forces, transverse forces in two directions at right angles to each other, and moments about three axes; the moments about the two axes in the plane of the section produce bending, and the moment about the axis of the bar produces torsion. The calculation of the system for any load can be made by the slope-deflection method. By neglecting the effect of normal forces, equations are obtained for determining the unknown rotations at the joints as equations of moment equilibrium at the joints (three for each joint). The fundamental equations for calculating the unknown displacements of the joints are given by the principle of virtual displacements applied to the deformation of the system caused by the change in length of an imaginary bar, if the system with articulations at the joints is provided with as many supporting bars as are necessary for a geometrically determinate system. This general method is carried out on the example of a frame consisting of a horizontal rectangle supported at the corners with fixed bars for connecting to the base. The frame is loaded with a vertical uniform load and with two horizontal forces at right angles to each other. The equations for unknown quantities can be divided into four groups, each containing four unknowns.

From author's summary by Folke K. G. Odqvist, Sweden

2815. **Courbon, Approximation methods for the calculation of frames** (in French), *Ann. Ponts Chauss.* **122,** 1, 27–65, Jan.-Feb. 1952.

An exposition is given of the slope-deflection and Cross methods with applications to the resolution of frames and calculation of secondary stresses in trusses. Reviewer believes author's conclusionis incorrect that, in symmetrical frames, the use of the Cross method is necessary to extend the calculation over the whole frame. Arturo J. Bignoli, Argentina

2816. **Stein, M., Anderson, J. E., and Hedgepeth, J. M., Deflection and stress analysis of thin solid wings of arbitrary planform with particular reference to delta wings,** *NACA TN* 2621, 53 pp., Feb. 1952.

The structural analysis of arbitrary solid cantilever wings by small-deflection thin-plate theory is reduced to the solution of linear ordinary differential equations by the assumption that the chordwise deflections at any spanwise station may be expressed in the form of a power series in which the coefficients are functions of the spanwise coordinate. If the series is limited to the first two and three terms (that is, if linear and parabolic chordwise deflections, respectively, are assumed), the differential equations for the coefficients are solved exactly for uniformly loaded solid delta wings of constant thickness and of diamond chordwise cross section with constant thickness ratio. For cases for which exact solutions to the differential equations cannot be obtained, a numerical procedure is derived. Experimental deflection and stress data for constant-thickness delta-plate specimens of 45° and 60° sweep are presented and are found to compare favorably with the present theory.

From authors' summary by T. H. Lin, USA

2817. **Flügge, W., Stress problems in pressurized cabins,** *NACA TN* 2612, 91 pp., Feb. 1952.

Report presents information on the stress problems in the analysis of pressurized cabins of high-altitude aircraft. Problems are divided into shell type for curved walls of cabin (assuming circular cylinder or shell of revolution) and plate type for plane rectangular panels framed by stiffeners. Some results of Kromm [*Jahrb. deutschen Luftfahrtforschung,* 1942, Bd. I, 596–601] for buckling of cylindrical panel are given. Both membrane and bending types of problem are considered. Report should be useful to designers of pressurized vessels in the estimation of

the stresses, and in the deformation of this type of structure.
Henry G. Lew, USA

2818. **Foster, S., Landing loads on the bogie undercarriage. A method of calculating the distribution of load on the wheels of a bogie undercarriage when landing,** *Aircr. Engng.* **24,** 275, 18–24, Jan. 1952.

Dynamic landing analysis has been made for a specific design. Example of calculated results is given for three different configurations during landing. Analysis is divided into four distinct phases separated by mechanical discontinuities. In each phase, linearity is assumed, providing elementary equations of motion. Analysis is made by straightforward step-by-step procedures. Reviewer's opinion is that too much algebra and incompletely defined notation detracts from value of paper for inexperienced engineers, while treatment is so specific that paper contributes little to the general design of landing gears.
C. Desmond Pengelley, USA

2819. **Moorman, R. B. B., Equivalent load method for analyzing prestressed concrete structures,** *J. Amer. Concr. Inst.* **23,** 5, 405–416, Feb. 1952.

Neglecting the longitudinal thrust, author establishes that, for most cases, the prestressing moment is equal to the bending moment of some fairly simple loading sequence. It is assumed that the cable is sliding freely inside its sheath and that, in the case of curve reinforcement, the slope is always small so that the horizontal component of the thrust is constant, and that the curve may be assumed indifferently as a circular arc or a parabola. The mathematics involved is quite easy to follow.
Robert Quintal, Canada

2820. **Kisiel, I., Nonsymmetrical bending of elements in reinforced concrete** (in Polish), *Inżyn. Budown.* **9,** 3, 95–99, Mar. 1952.

Author assumes a beam of rectangular cross section loaded by two moments acting in horizontal and vertical planes. By means of elementary arithmetic, he derives formulas for stresses and for required cross sections. The paper makes an odd impression since, in each Institute of Technology, students are taught to derive, by means of elementary integrals, general equations for stresses and for more complicated cross sections than those in the paper. Thus, paper shows the simplest particular example. Paper is full of formulas for area of trapezoid, roots of second-degree algebraic equation, etc. Author suggests that the best way of solving algebraic equation of third degree is by means of trial-and-error method (reviewer notes exact way is in hundreds of textbooks).

At the beginning, author puts forward a statement that vector of moment of internal forces must coincide (having opposite sign) with the vector of the external forces. Next, he says that it is completely obvious, and, finally, he proves it indirectly, i.e., if there is a difference between those two vectors it must be added to vector of moment of internal forces, since another is given. Since author assumes equilibrium conditions, all this is unnecessary. Numerical examples close the presentation.
M. Z. Krzywoblocki, USA

2821. **Morgan, V. A., The design of an unusual bow girder,** *Concr. constr. Engng.* **47,** 2, 5; 47–55, 148–149; Feb., May 1952.

A description of the design of a reinforced-concrete bow girder with 90° horizontal curve, continuous over supports and carrying column loads along its length. Author gives equations based on least-work method for deriving design moments and torques. Continuous helical reinforcing inclined at 45° is provided to resist torque. Design of helical reinforcing is discussed on empirical basis with reference to formulas of Seely, Rausch, et al.
Irwin A. Benjamin, USA

2822. **Campbell, W. R., Irwin, L. K., and Duncan, R. C., Stress studies of bulkhead intersections for welded tankers,** *Weld. Res. Suppl.* **17,** 2, 68s–75s, Feb. 1952.

In this extension of an earlier paper, four full-sized bulkhead intersections, of different design, for welded tankers were strained elastically at room temperature for stress distribution and to failure at 0 F, in an effort to duplicate brittle fracture characteristic of service failures. Strain distribution prior to failure at 0 F and energy for failure at 0 F were measured. All specimens sustained considerable elongation, but showed brittle fractures.
George V. Smith, USA

2823. **Esslinger, Maria, Shrinkage and creep in composite beams** (in German), *Bauingenieur* **27,** 1, 20–26, Jan. 1952.

When a composite beam (rolled steel shape for web and concrete flange) is to carry negative bending moment, the concrete may be prestressed so that the entire section will be active. The concrete prestress diminishes with time due to creep and shrinkage. Based on Froehlich [title source, **24,** p. 300, 1949] and Fritz [*Bautechnik* **27,** p. 37, 1950], author calculates the effects of concrete creep and shrinkage on the internal forces of the composite beam. Illustrations are given, including statically indeterminate cases.
M. P. White, USA

2824. **Mackey, S., and Williamson, N. W., Experimental investigation of a 33-ft span lattice girder,** *Publ. inter. Assn. Bridge struct. Engng.* **11,** 303–324, 1951.

The structure tested was a steel truss with double-angle chords and single-angle web members. Connections were bolted. Strains and deflections were measured for several increments of loading, applied at two symmetrically spaced panel points on the upper chord. Failure occurred when a vertical web member under one of the loads buckled in a direction normal to the plane of the truss.

Authors find good agreement between measured and computed direct forces in the members but relatively poor agreement between measured and computed secondary bending moments. They conclude that the effective length of web compression members should be taken as the full length between center lines of chords for bending normal to the plane of the truss, and should be taken as 0.50 to 0.75 of the full length when considering bending in the plane of the truss.
John W. Clark, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2834, 2842, 2844, 2868)

2825. **Thomas, T. Y., On the characteristic surfaces of the von Mises plasticity equations,** *J. rational Mech. Analysis* **1,** 3, 343–357, 1952.

It is shown that, under the assumption of the von Mises yield function and potential, two real characteristic surface elements exist at each point in a plastic zone if, and only if, the local strain rate is a pure shear. The surface elements coincide with the planes of numerically greatest shearing stress.
R. Hill, England

2826. **Servi, I. S., and Grant, N. J., Creep and stress rupture as rate processes,** *J. Inst. Metals* **80,** 33–37, 1951–1952.

An analysis of minimum creep-rate values for S-590 shows that

log minimum creep rate is not linear with stress for a certain wide range of rates, but it is linear with log stress. The data could be expressed empirically as

$$\log \text{min. creep rate} = \text{const} + \left(\frac{\text{const}}{\text{abs temp}} - \text{const}\right)(\log \text{stress-const})$$

J. D. Lubahn, USA

2827. **Schwope, A. D., Shober, F. R., and Jackson, L. R., Creep in metals,** *NACA TN* 2618, 52 pp., Feb. 1952.

This report deals with creep tests on single crystals of high-purity aluminum. The emphasis is on the shape of the strain-vs-time curve during the very early stages of the creep test. Various theories which would predict the shape of this curve are studied. Creep tests were carried out for a few hundred hours, but only that strain which occurred during the first hour was compared with theory. The best agreement, especially at the lower stresses, was obtained when the test curves were compared with the theoretical curve of Mott and Nabarro [AMR **3**, Rev. 695] which has the form $\epsilon = AT^{2/3}(\ln \nu t)^{2/3}$, where ϵ is strain, T temperature, t time, and A and ν are constants. It was found that the critical resolved shear stress for the high-purity aluminum used was between 20 and 30 psi, and that the creep was more directly related to the resolved shear stress than to the tensile stress. Evan A. Davis, USA

2828. **Kramer, I. R., and Maddin, R., Delay time for the initiation of slip in metal single crystals,** *J. Metals* **4**, 2, 197–203, Feb. 1952.

The delay times for initiation of slip in single crystals of face-centered cubic aluminum and α-brass and body-centered cubic β-brass were investigated between room temperature and -190 C. The stresses were held at a constant value over time intervals as short as 8×10^{-5} sec, using a technique involving impact of pendula and traveling longitudinal waves in metal rods. Production of visible slip lines coincided with occurrence of permanent strain.

A delay time was found for β-brass which increased as the temperature was lowered, but none was found for aluminum or α-brass. The theory is proposed that body-centered cubic metals exhibit a temperature-dependent delay time, while face-centered cubic metals have a very small delay time or none at all, and that this is the reason for the occurrence of a brittle transition temperature in body-centered cubic metals. The existence of a delay time for the initiation of slip will permit a specimen to be loaded at a rate sufficiently rapid that the delay time is nowhere exceeded. Under these conditions, plastic deformation cannot occur and the specimen must fail by cleavage.

S. B. Batdorf, USA

2829. **Paxton, H. W., Adams, M. A., and Massalski, T. B., Some observations on slip lines in iron,** *Phil. Mag.* (7) **43**, 337, 257–258, Feb. 1952.

Slip lines on the polished surface of body-centered cubic iron single crystals were found sensitive to the state of preparation of the surface. Those produced by an extension of 0.5% on a mechanically polished surface, or on an electro-polished surface which had been lightly rubbed with fine polishing alumina, showed a separation of lines of the order of magnitude 5 to 10 μ. If the crystal face were electro-polished to a depth of 10 μ or more, very fine slip lines were produced with separation of approximately 2 μ. At intermediate depths of electro-polishing, two types of slip lines were found; the coarse lines branching at the boundary of the band to form the fine ones. Hans F. Winterkorn, USA

2830. **Cumper, C. W. N., and Alexander, A. E., The viscosity and rigidity of gelatin in concentrated aqueous systems. I. Viscosity. II. Rigidity,** *Austral. J. sci. Res.* (*A*) **5**, 1, 146–159, Mar. 1952.

The viscosity of gelatin solutions at concentrations between 100 and 500 g/l has been studied as a function of pH, ionic strength, and temperature. In these concentrated systems, the predominant factor determining the viscosity appeared to be Coulombic forces between ionized groups on adjacent chains.

The rigidity of the gels formed by cooling the systems considered in part I was also measured. The results obtained have been explained by postulating a network of the gelatin molecules held together by electrostatic bonds.

From authors' summary

2831. **Holden, A. N., Dislocation collision and the yield point of iron,** *J. Metals* **4**, 2, 182–188, Feb. 1952.

Paper discusses only yielding of iron containing carbon, although analysis can be extended to other metal-solute systems. The Cottrell mechanism of yield is summarized and extended to account for strain-aging effects and difference in behavior of single and polycrystals. The dislocations which must propagate to produce slip lie at the centers of local concentrations of carbon atoms, and these carbon clouds anchor the dislocations. Yield point occurs when the first dislocation breaks free, enabling others to break free by interaction, and the cataclysmic local deformations appear as Lüders bands. Some small prestrain is required to produce sufficient dislocations in an annealed iron crystal to cause a yield point, the yield point being the result of strain-aging during which carbon diffuses to and anchors the dislocations. Polycrystals already contain sufficient dislocations at grain boundaries to cause a yield point. Paper contains confirming theoretical and experimental work.

Jacques Heyman, England

Failure, Mechanics of Solid State

2832. **Slattenschek, A., Ductile and brittle behavior of metallic materials under mechanical stresses** (in German), Alfons Leon Gedenkschrift, Verlag Allg. Bau-Z., Wien = *Schweissen Schneiden* **3**, Sonderheft, 90–100, 1951.

Papers deal with the application of Mohr's rupture theory, combined with Leon's envelope to explain the failure of metallic and nonmetallic materials. Modifications of the rupture state due to fabrication influences and stress state are also intended to be explained by Mohr's theory. Author establishes four principal influences that cause the brittle fracture of materials which may be considered as ductile from simple tension tests. Some practical examples are also shown, among others a welded joint, where three different zones are stated, in which the material is ductile or brittle.

Reviewer believes that Mohr's theory cannot be extended to any class of materials, since it does not consider the intermediate stress. Hencky-von Mises' greatest distortion theory explains the failure of ductile materials better than Mohr's. Leon's envelope leads also to fundamental errors if used to establish the triaxial tension failure. Enrique D. Fliess, Argentina

2833. **Muller, R. A., On the question of the statistical theory of brittle strength** (in Russian), *Zh. tekh. Fiz.* **22**, 3, 461–466, Mar. 1952.

Theory discussed is "weakest link" theory of size effect in frac-

ture strength, especially as developed by Kontorova and Frenkel [*Zh. tekh. Fiz.* **11**, p. 137, 1941; for bibliography and criticism of this and related theories, see Epstein, AMR **1**, Rev. 460]. If F_1 and F_2 are the cumulative distribution functions of strengths for specimens of volumes V_1 and V_2, respectively, the weakest link theory gives $1 - F_2 = (1 - F_1)^x$ ... [1], with $x = V_2/V_1$. Author gives procedure and numerical table for estimating mean and variance of F_2, given mean and variance of F_1. The table is based on the normal distribution, and the procedure involves, at successive stages, the assumption that each of the two distributions (F_1, F_2) is normal. Since simultaneous normality of both is incompatible with [1], reviewer believes that author's procedure, if legitimate, requires more elaborate justification than he has given. William Fuller Brown, Jr., USA

2834. Roš, M., Experiments for the determination of the influence of residual stresses on the fatigue strength of structures (in French), *Rev. Soudure* **8**, 1, 23–39, 1952 = *Welding Res.* **4**, 5, 83–93, Oct. 1950 (in English).

Experiments are described in which the tensile fatigue strengths of several structural steels are determined at one million cycles for uniform specimens and for specimens containing a transverse hole without plugs, containing loose plugs, shrink-fitted plugs, pressed tapered plugs, and welded plugs. The yield strengths for the structural steels were between 20 and 29 kg per sq mm and the fatigue strengths in axial tension between 28 and 34 kg per sq mm.

Author concludes that the residual stresses have little effect on the fatigue strength of structures made from structural steel. The experimental data presented justify the conclusion. Reviewer thinks that this should be the expected result, for the applied fatigue stress slightly exceeded the yield strengths of the structural steel, thereby relieving any initial residual tensile stresses and perhaps even inducing compressive stresses as high as those induced by the plugs or welds. For metals which have yield strengths considerably higher than the fatigue strengths, initial residual stresses might have considerable effect, for they would not be completely altered by the stress cycle.

George H. Sines, USA

2835. Schaal, A., On the question of size effect on bending-yielding and bending-vibration resistance (in German), *Z. Metallk.* **42**, 9, 279–284, Sept. 1951.

The increase in fatigue strength in bending accompanying decrease in thickness of specimens has been attributed to the steeper slope of the bending-stress curve for narrower specimens and, alternatively, to the presence of fine surface cracks whose depth depends on the specimen thickness.

Author determined by x-ray methods the static yield stress of the surface fibers, both in tension and in bending, for three materials: Alloy steel, carbon steel, and aluminum alloy. The static yield stress in bending was found to increase with decrease in thickness of the specimens. Author concludes that this effect is due to the steeper slope of the stress curve in thinner specimens.

Reviewer believes this conclusion is correct, since recent experiments [Backer, W. R., Marshall, E. R., and Shaw, M. C., see AMR **5**, Rev. 2390; Walker, W. E., Turner, T. J., and Beams, J. W., "Mechanical properties of thin films of silver," presented at A.P.S. Ann. Meet., Jan. 31, 1952; Herring, C., and Galt, J. K., "Elastic and plastic properties of very small metal specimens," *Phys. Rev.* **85**, 1060–1061, Mar. 15, 1952] have shown that thin metal layers tend to have a higher yield stress than thick ones.

Author's results of size effect on yield stress in static bending correlate well with those for fatigue strength taken from literature. B. G. Rightmire, USA

2836. Irwin, G. R., and Kies, J. A., Fracturing and fracture dynamics, *Weld. Res. Suppl.* **17**, 2, 95s–100s, Feb. 1952.

Paper deals with application of classical concepts of fracture propagation to safe fracture design. Methods are presented for evaluating both the change in the work of deformation and the change in the released strain energy with increasing crack area. Author concludes that the relative magnitude of the two aforementioned quantities determines whether cracks propagate.

A. N. Holden, USA

2837. Matthaes, K., Considerations on the theory of strength of materials (in German), *Z. Metallk.* **43**, 1, 3; 11–19, 90–95; Jan., Mar. 1952.

This tutorial paper summarizes present theories of rupture, plastic flow, stress corrosion, creep, fatigue, notch sensitivity, and cold brittleness of metals and alloys. Concepts of heat of fusion and cold-work energy are used, together with a Pascal distribution of inhomogeneities, as bases for discussion. Detailed comparisons with experimental results in graphs and tables provide valuable information. Most of the references are German.

Vincent Salmon, USA

Material Test Techniques

(See also Revs. 2834, 2844, 2850, 2856)

2838. Lutsch, A., Nondestructive testing of materials by supersonics with the pulse-timing-echo method (in German), *Arch. Eisenhüttenw.* **23**, 1/2, 57–65, Jan./Feb. 1952.

Longitudinal waves as well as shear waves of ultrasonic frequencies are being used for nondestructive testing of engineering structures. The best known equipment for this purpose is the reflectoscope.

The directional characteristics of these waves can be selected by the choice of the wave length λ and the diameter D of the transducer. Divergence of the energy takes place at a distance $l = D^2/4\lambda$ from the transducer. (Author gives $l = D^2/4\lambda$ as the distance from the transducer which the sound beam travels before diverging appreciably.) Up to this distance the energy can be considered as contained in a cylinder. The coupling of the transducer to the workpiece is of importance. The energy transfer can be improved by insertion of tin or copper foil between the transducer and the testpiece. The thickness of the foil for frequencies of 2.5 to 5 mcps is 1 to 3 mils.

The nondestructive testing of welds is accomplished by transmitting ultrasonic waves into the material under an angle. For this purpose, a compressional wave is sent into the material under an acute angle. This compressional wave produces shear waves at the interface. These shear waves are important for the detection of flaws in the weld.

Most of the material in this paper has been reported previously in the literature, particularly by F. Firestone ["Nondestructive testing," 1948, p. 5]. Robert O. Fehr, USA

2839. Roop, W. P., The notch toughness test of Henri Schnadt, *ASTM Bull.* no. 179, 61–64, Jan. 1952.

2840. Smack, J. C., Basic principles of practical ultrasonic testing, Symp. Ultrason. Test., *ASTM Spec. tech. Publ.* 101, 62–71, 1951.

Author describes types of ultrasonic-testing instruments and their various uses in the field of measurement and nondestructive examination of materials. Louis F. Coffin, Jr., USA

Mechanical Properties of Specific Materials

(See also Revs. 2827, 2828, 2829, 2839, 2863)

2841. **Doepken, H. C., Tensile properties of wrought austenitic manganese steel in the temperature range from +100° to −196° C,** *J. Metals* **4,** 2, 166–170, Feb. 1952.

Doepken tested wrought Hadfield steel at temperatures from 100 to −196 C. Tensile specimens of 1-in. gage length and 0.25-in. diam were used. The yield strength was not greatly affected until the testing temperature was below 100 C; it then increased rapidly as the testing temperature was reduced, until at −196 C it was about twice its value for room temperature. The fracture stress decreased continually with decrease in temperature, and ductility dropped rapidly as the testing temperature fell below −100 C.

Author considers that there is evidence of mechanical twinning or martensite formation during the deformation of this steel.

J. A. Pope, England

2842. **Pickus, M. R., and Parker, E. R., Creep behavior of zinc modified by copper in the surface layer,** *J. Metals* **3,** 9, 792–796, Sept. 1951.

Authors describe the results of experiments in which single crystals and polycrystalline specimens of zinc were tested in creep at various temperatures. These specimens were surrounded by a container so that the surface of the specimens could be cleaned by an anodic treatment or covered with copper by electrodeposition. For single crystals of zinc, the creep rate is considerably reduced when the surface is plated with copper; the higher creep rate reappears when the surface is anodically cleaned. This cycle can be repeated with the same results. For polycrystalline zinc, however, no significant effect was observed. Using the reaction-rate theory, which assumes that the creep rate is proportional to $e^{-Q/RT}$, authors found that the activation energy Q was the same for clean single crystals and for clean and plated polycrystalline zinc, and was substantially different for plated single crystals.

They conclude that the effect of plating single crystals is not a mechanical one but probably one which acts as a barrier which impedes the generation of dislocations at the surface or prevents the escape of internally generated dislocations. Further tests are being planned to check these mechanisms.

M. J. Manjoine, USA

2843. **Wylie, R. D., and Thielsch, H., Creep and stress-to-rupture properties of pressure vessel steels,** *Weld. Res. Suppl.* **17,** 1, 11s–19s, Jan. 1952.

Elementary review of nature of creep and stress-rupture properties of steel. Summary, taken from boiler codes, covers maximum allowable stress for pressure-vessel steels.

B. J. Lazan, USA

2844. **Graham, A., Phenomenological theories of creep,** *Engineer, Lond.* **193,** 5011, 5012; 198–201, 234–236; Feb. 1952.

A formula for uniaxial creep is given as $\sigma/\sigma_s = \epsilon^m(\dot{\epsilon}/\dot{\epsilon}_s)^{qT}$ where σ is the stress, ϵ the plastic part of the elongation, T the absolute temperature, and σ_s, $\dot{\epsilon}_s$, m, and q are constants. This equation embraces several empirical laws of creep, such as the Nutting equation and the equation of Hollomon and Lubahn. The equation may also be used to show a connection between creep and tensile-test behavior so that different forms of the creep curve can be associated with different forms of the stress-strain curve.

The general equation fits most creep data quite well, but in some cases may not be quantitative enough for the engineer's use. Its strength lies in its applicability to many types of materials over a range of conditions. The equation has the smallest number of constants consistent with the number of variables.

Lawrence Nielsen, USA

2845. **Avery, H. S., Hard facing for impact,** *Welding J.* **31,** 2, 116–143, Feb. 1952.

Engineering aspects of factors that influence wear due to impact and techniques for combatting this wear are discussed. Hard facing, an important technique for combatting wear, involves use of martensitic irons, martensitic steels, and austenitic steels. Pertinent static and dynamic data on the three above alloys are presented. The importance of proper engineering to avoid tension is stressed. Critical limitations of impact energy and velocity are suggested to minimize structural damage and to help in alloy selection. Composite structures to control wear are also discussed.

Author states that paper is intended to help engineers cope with the problems of industrial wear. Reviewer feels that paper is a valuable contribution to technology of impact resistance.

J. S. Rinehart, USA

2846. **Case, S. L., Berry, J. M., and Grover, H. J., Fatigue strength of large, notched steel bars surface-hardened by gas heating and by induction heating,** *Trans. Amer. Soc. Metals* **44,** 667–683, 1952.

Authors report on rotating-beam fatigue strength of notched and surface-hardened SAE 1045 steel. Specimens tested had a root diameter of 1.69 in. at the circumferential V-notch designed to produce a stress-concentration factor of approximately 2. The unhardened specimens were found to have a nominal fatigue strength of 15,000 psi at 2 million cycles. Specimens with a case of 0.130 in. had a fatigue strength of approximately 50,000 psi, while those with a case 0.225 in. deep were even stronger at 80,000 psi. For a particular case depth, authors report no significant difference in fatigue strength with difference in the method of heating employed.

Reviewer believes that authors did not test enough specimens of each type, particularly in view of the large amount of scatter of the test points on the S-N chart.

Alexander Yorgiadis, USA

2847. **Lawson, D. I., The fire endurance of timber beams and floors,** *Struct. Engr.* **3 (30),** 2, 27–33, Feb. 1952.

On the basis of semi-empirical studies, the fire endurance, defined as a ratio of applied load over breaking load, can be calculated according to given formulas. It is proportional to the square root of the cross-sectional area. For a given cross-sectional area and corresponding fiber stress, a beam having a square section will give the longest fire endurance. A beam selected on this basis will, of course, not result in greatest timber economy.

E. G. Stern, USA

2848. **Cheatham, R. G., and Dietz, A. G. H., Effect of orientation on the mechanical properties of polystyrene,** *Trans. ASME* **74,** 1, 31–40, Jan. 1952.

Extruded polystyrene rod was first annealed and then stretched hot to elongation as high as 12,000%. Tests were made in tension, flexure, and torsion at temperatures ranging from 0 to 80 C. Tests included creep and relaxation as well as tests at strain and load rates ranging as high as 1.0 in./in./min and 10,000 lb per min to determine the effect of orientation upon these mechanical properties. Tensile and flexural strengths increased two to threefold, depending upon rate and temperature; torsional strength decreased; and modulus of elasticity increased moderately. Fracture changed from a sharp break to a fibrous separation.

Birefringence measurements revealed marked orientation of the material, but low-angle x-ray diffraction studies revealed no "crystalline" structure.

From authors' summary by Joseph Marin, USA

2849. **Quackenbos, H. M., Jr., and Hill, J. M., Effect of absorbed water on physical properties of phenolic plastics,** *Trans. ASME* **74,** 1, 41–50, Jan. 1952.

The absorption of water by phenolic plastics obeys Fick's law and can be described completely by a saturation constant, a diffusion constant, and a simple relation between diffusion constant and temperature. Two important consequences of water absorption are that mechanical properties change and all dimensions expand, the magnitude of each seeming to remain roughly constant for each per cent of water absorbed. In practice, expansion may give rise to undue warping and high stresses and is directly connected with dimensional stability. It is shown how these effects may be analyzed rationally by using the coefficient of expansion and the constants describing absorption.

From authors' summary by L. E. Nielsen, USA

2850. **Buist, J. M., Abrasion and wear of rubber,** *Engineering* **173,** 4489, 169–171, Feb. 1952.

This paper reviews recent developments on abrasion or smear tests of rubber. It points out that abrasion follows the equation $y = ax^n$, where y is weight or thickness loss, x time of abrasion, and a, n are constants determined by type of rubber and test conditions. This equation applies for both laboratory and road tests, and accurately predicts ultimate wear on the basis of short-term tests.

Charles E. Crede, USA

2851. **Gent, A. N., and Rivlin, R. S., Experiments on the mechanics of rubber. I: Eversion of a tube,** *Proc. phys. Soc. Lond. (B)* **65,** part 2, 386B, 118–121, Feb. 1952.

This paper consists of a further experimental check of a theory of large elastic deformations of materials. This theory [Mooney, M., *J. appl. Phys.* **11,** 582, 1940; Rivlin, R. S., AMR **3,** Rev. 2212] assumes that the elastic properties of an ideal, incompressible, isotropic, and highly elastic material can be specified by a stored energy function which must be a function of the strain invariants.

Experiments are described in which three circular cylindrical tubes of a natural rubber vulcanizate were turned inside out. An indirect form of comparison of the experimental and theoretical values of the strains showed close agreement.

Yoh-Han Pao, USA

2852. **Doyle, P. J., Some fundamental properties of hosiery yarns and their relation to the mechanical characteristics of knitted fabrics,** *J. Text. Inst. Proc.* **43,** 1, P19–P33, Jan. 1952.

Author discusses relation between mechanical properties of knitted fabric and those of the component yarns and states that both flexural and torsional deformations are involved. Friction between separate yarns is also of importance. No definite conclusions are reached except that much further work in this field is desirable.

H. Kolsky, England

2853. **Fisher, J. C., and Dunn, C. G., Surface and interfacial tensions of single-phase solids,** "Imperfections in nearly perfect crystals;" New York, John Wiley & Sons, 317–343, 1952. $7.50.

The published values of surface and interfacial tensions of single-phase solids are collected, evaluated, and tabulated. Several errors in the literature are corrected. Reasonably good values are obtained for the surface tensions of solid copper, silver, and gold, for the grain and twin-boundary tensions in copper, and for the variation in grain-boundary tension with orientation of the adjacent grains in silicon iron, tin, and lead.

From authors' summary

2854. **Frey, D. N., Freeman, J. W., and White, A. E., Fundamental effects of cold-work on some cobalt-chromium-nickel-iron base creep-resistant alloys,** *NACA TN* 2586, 12 pp., Jan. 1952.

This fifth report of a series dealing with the fundamental factors influencing the creep properties of alloys for use in aircraft propulsion systems describes the influence of cold-working on the creep properties of an alloy subjected to minor changes in chemical composition.

Authors have concluded from earlier work [AMR **5,** Rev. 1427] that there are certain correlations among creep properties, internal stresses, and width of x-ray diffraction lines. Using these relationships, effects of cold work on a cobalt, chromium, nickel, iron alloy were evaluated for four different minor chemical changes in the base alloy.

Base alloy and its variations all showed same creep behavior after cold work, indicating that internal stress-relaxation characteristics of alloys examined are independent of minor changes in chemical compositions.

Philip K. Roos, USA

2855. **Tabor, D., Hardness and strength of metals** (in French), *Rev. Métall.* **49,** 3, 208–210, Mar. 1952.

Paper concerns relationship between hardness, yield stress, and strain. It is essentially an abstract of Tabor's paper reviewed in AMR **4,** Rev. 3577.

J. H. Palm, Holland

2856. **Allen, N. P., Notched bar testing of mild steel,** *Nature* **169,** 4295, 307–309, Feb. 1952.

Paper is a summary of five papers and discussion of Symposium organized by the Institute of Welding and Joint Committee on Materials.

First paper by W. Barr and J. M. MacKenzie illustrated the point of steelmakers, who are actually able to supply mild steels in several grades of toughness. Authors conclude if notched bar test is necessary, the Izod V-notch test is as good as any; the test should, however, be done at the expected transition temperature.

In his paper, Mr. Boyd did not agree with this view; his tests showed that there is no relation in results of different kinds of test pieces. It seems necessary to separate crack initiation and crack propagation. This is impossible in an impact test. Author proposes the use of large test piece and control of type of fracture.

The same opinion was expressed by Mrs. Tippers in her paper; no relation was found between standard impact tests and behavior in service. Correlation was good with tensile test on larger notched test pieces.

Dr. J. van der Veen described the static bend test used by the Netherlands steel works. Area of crystalline part of fracture measures grade of brittleness at test temperature.

In his paper, Prof. W. Soete tried to follow change of state of stress in notched cylindrical tensile test at different temperatures. Triaxiality seems not to be markedly influenced by plastic deformation.

During discussion, several speakers emphasized the necessity of a simple test for testing small volumes of weld or heat-affected metal. Dr. Robertson described an ingenious test allowing determination of tensile stress and temperature which stop an initiated crack. Most important difference in opinion was the assessing of results, should crack initiation or crack propagation be taken as criteria.

Points of agreement included: Need of mild steel with controlled toughness; present British standards are not suitable; uncertainty in toughness required for particular applications; need of study of behavior of weld and heat-affected metal.

W. Soete, Belgium

2857. **Vitovec, F., On the temperature dependence of Poisson's ratio for metals** (in German), *Öst. Ing.-Arch.* **6**, 2, 132–134, Jan. 1952.

The temperature dependence of Poisson's ratio for a number of metals proves Young's modulus and the modulus of compressibility. The temperature dependence of Young's modulus has been found experimentally. The temperature dependence of the compressibility modulus is calculated from the lattice energy. It is found that Poisson's ratio increases with temperature. For aluminum, for example, Poisson's ratio increases from 0.333 at zero degrees absolute to 0.400 at the melting point.

M. P. White, USA

2858. **Edeleanu, C., A mechanism of stress-corrosion in aluminium-magnesium alloys,** *J. Inst. Metals* **80**, 187–191, 1951–1952.

Author outlines procedures and reports results of stress-corrosion studies on Al-7% Mg alloy. Chemical measurement of the amount of aluminum in solution after a given time of immersion in acidic NaCl and KCl solutions showed no significant effect of stress on rate of corrosion. Reviewer feels that a magnesium determination should also have been made. Microscopic examination during last stages of the process was accomplished by use of a water immersion lens. When evolution of hydrogen bubbles is taken as an indication of corrosion rate, it was observed that the stressed specimens underwent an increased rate of corrosion just before failure. Relaxation of stress was followed by an eventual slow-down of hydrogen evolution. The propagation of cracks, once started in stressed specimens, was stopped by making the specimen cathodic, showing that corrosion plays an important part in growth of cracks. Susceptibility to stress-corrosion attack was found to be made greater by increasing the aging time at 200 C, up to about 6 days aging. Beyond this point, susceptibility shows a decrease. Carl A. Keyser, USA

2859. **Romer, J. B., and Newell, H. D., The creep and stress-rupture testing of steam-boiler materials,** *Trans. ASME* **74**, 2, 157–172, Feb. 1952.

Authors stress importance of time element in tests of materials for long-life, high-temperature service. Possibility of intergranular corrosion and/or structural changes in material necessitates tests of long duration, whether of creep or stress-rupture variety. Question of relative importance of creep and rupture testing of materials for long-life application thus is left unsettled. Authors suggest temperature limits for superheater-tube materials and give typical creep and rupture data (with a resumé of field experience) for various carbon and alloy steels.

L. Green, USA

2860. **Bentele, M., and Lowthian, C. S., Thermal shock tests on gas turbine materials,** *Aircr. Engng.* **24**, 276, 32–38, Feb. 1952.

Authors propose a rational method for evaluating the resistance of machine parts to fatigue by thermal stresses. The nonuniform, nonsteady temperature distribution in the part is calculated from the heat-conduction equation. The thermal stresses attending this distribution are then computed. Authors note the possibility that comparison of these stresses with the known fatigue behavior of the material might yield a measure of the expected performance of the part. This procedure would be identical to that employed by Cheng [*J. Amer. Rocket Soc.*, 147–153, Nov. 1951; see AMR **5**, Rev. 2297]. Their approach leads to a criterion for thermal shock resistance which is in agreement with published tests and with new experiments by the authors, and which supports the correlation of Lidman and Bobrowsky [AMR **3**, Rev. 2340]. Authors' tests of turbine nozzle blades cast in austenitic steel emphasize the need for further investigation of the effect of variables not considered in their theoretical study, such as surface conditions and grain-boundary corrosion.

L. Green, USA

Mechanics of Forming and Cutting

2861. **Vardhan, H., Machining of diamonds for technical purposes,** *J. sci. indust. Res. India* **2**, 3, 95–108, Mar. 1952.

Paper deals with the various laboratory techniques for the preparation of diamond-turning tools, glazier's pen, and diamond wire-drawing dies. Because of the strong directional properties of the diamond to resist cleavage, the top surface of a lathe-turning tool should be kept in close parallelism to the rhombic planes of the crystal, which is a rhombic dodecahedron. The first step involved in preparing a diamond lathe tool is the cutting of the crystal along a prescribed crystallographic plane. This is done on a machine equipped with phosphor-bronze circular cutting blade capable of rotating at 4000–6000 rpm. The edge of the blade is charged with diamond powder of 100–120 mesh. Lapping is carried out on horizontal cast-iron disks with finer pastes of diamond powders in olive oil.

Resistance of a diamond to abrasion along different crystallographic directions varies widely. A cubic face can be ground without difficulty in directions parallel to the sides but not in directions along the diagonals of the face. Author illustrates with sketch the proper grinding or lapping directions along cubic (100), octahedral (111), and dodecahedral (110) planes.

Drilling of diamond dies is usually preceded by polishing and indenting the surface. The latter operation serves as a starting point for the drill which has the form of a needle. Diamond powder in olive oil is also used to produce the cutting action. Since cleavage fracture is the main cause of die failure, holes should be drilled normal to the octahedral, dodecahedral, or cubic planes. Drilling perpendicular to the cubic (100) planes gives the least trouble. B. T. Chao, USA

2862. **Polakowski, N. H., Russian practice in machining with cemented carbides,** *Machinery, Lond.* **80**, 2054, 540–543, Mar. 1952.

General purpose HSS contains 8.5 to 10% W, 2.5% V, 4% Cr. Use of the 18-4-1 HSS is restricted. Carbides are used extensively in Russian industry. Compositions are given and contain up to 97% WC; 5–30% TiC; 3–12% Co; 6% Ni. Most of these grades have been developed since 1945.

General purpose turning tools have negative rake angles. Tables for recommended cutting speeds and power requirements are given. Graph illustrates relation between feed and tool life for machining austenitic steel at various speeds. Lathe tools with a negative ridge superimposed upon a positive rake angle and tools with small end and side-cutting edge angles have been introduced. A. O. Schmidt, USA

2863. **Chadwick, R., and Hooper, W. H. L., Some observations on the occurrence of stretcher-strain markings in an aluminum-magnesium alloy,** *J. Inst. Metals* **80**, 17–22, 1951–1952.

Detailed observations have been made of the appearance of

and dimensional distortion associated with surface markings developed by the progressive stretching of aluminum 3%-magnesium alloy sheet in different conditions of cold-working and annealing. In material of 0.025-mm grain size, markings develop with a very small strain, and are at first normal to the tension axis but subsequently become random in direction, reaching maximum intensity at about 1%, and decaying within a 2% extension. These random markings consist of a series of kinks, and there is no thinning of the sheet. Parallel, intersecting bands or shallow grooves at a definite angle to the direction of stretching first appear at about 2% extension and increase progressively in intensity up to the point of fracture. Parallel bands, which are caused by local thinning or necking, are of much less intensity than the random markings, which are the main cause of defects in pressing operations.

From authors' summary by A. O. Schmidt, USA

2864. **Geleji, A., Calculation of the resistance to deformation and of power consumption in rolling** (in German), *Acta Techn. Hung., Budapest* **1**, 1, 78–108, 1950.

This article consists of a theoretical analysis based on a number of simplifying assumptions, the justification of which is not too clear as far as the theory goes; but when one considers the correlation between experimental and calculated results, one is impressed by the fact that the assumptions must have been fairly reliable. Of particular value are the charts from which one can predict the amount of reduction per pass for the rolling of aluminum alloys. The results are wisely shown as a band or zone because there seems no clear line of demarcation to indicate the best practice. Nevertheless, an average line is shown which would represent a practical design value. The importance of this paper can easily be underestimated unless one is aware of the difficulty of establishing a reliable correlation between theory and practice in the rolling of metals. R. G. Sturm, USA

Hydraulics; Cavitation; Transport

(See also Revs. 2756, 2830, 2853, 2873, 2874, 2923)

2865. **Richardson, E. G., Turbulence and silt-load in water channels,** *Öst. Ing.-Arch.* **6**, 2, 86–92, Jan. 1952.

Article gives brief summary of theoretical aspects and physical measurements of turbulence parameters and describes a good apparatus for analyzing silt loads in channels.

Dwight F. Gunder, USA

2866. **Mints, D. M., On the suspension of a granular layer in an upward stream** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **82**, 1, 17–20, Jan. 1952.

The coefficient of resistance in vertical flow through a bed of particles depends on a generalized Reynolds number where the characteristic length is the ratio of the porosity to the area-volume ratio of the particles. Limited experimental data are given in justification, and nomograph procedure is set up to correlate observables with parameters such as porosity.

Newman A. Hall, USA

2867. **Ismail, H. M., Turbulent transfer mechanism and suspended sediment in closed channels,** *Proc. Amer. Soc. civ. Engrs.* **77**, Separ. no. 56, 26 pp., Feb. 1951.

Paper describes tests on transport of suspended sediment in a closed rectangular flume. Results were used to study, in the light of turbulent mixing theory, the effect of suspended sediment on the characteristics of the flow and the distribution of momentum and sediment-transfer coefficient.

Von Kármán's universal constant decreases under the increase of the suspended load, indicating a damping of the turbulence. The head-loss coefficient for all concentrations was hardly affected by the presence of sediment when the velocity of the flow was able to carry all the sand in suspension. The sediment-transfer coefficient was found to be 1.5 times the momentum-transfer coefficient for a 0.10-mm sand, and 1.3 times this coefficient for a 0.16-mm sand. Both coefficients follow the normal parabolic form at the outer two thirds of the channel and have a constant value at the middle third.

G. A. T. Heyndrickx, Belgium

2868. **Magnusson, K., Dependence of power consumption on the effective viscosity when agitating liquids of viscous structure** (in Swedish), *IngenVetenskAkad. Tidsk. Tekn. Forsk.* **23**, 2, 86–99, 1952.

When agitating non-Newtonian suspensions or liquids, the power consumption has a certain relation to the apparent viscosity. In order to determine this viscosity, a Newtonian liquid has first to be agitated in a mixing tank and a Power-number-*Re*-diagram to be drawn of the experimental results; then the non-Newtonian suspension or liquid is agitated in the same tank. The *Re*-number values corresponding to the new Power-number values thus obtained will be derived from the above diagram, and, from these, *Re*-number values of the apparent viscosity can be deduced. From author's summary

2869. **Kampmeyer, P. M., The temperature dependence of viscosity for water and mercury,** *J. appl. phys.* **23**, 1, 99–102, Jan. 1952.

Expressions suggested by the theory of Eyring for smoothing experimental viscosity data for water are applied. The Arrhenius expression for the variation of viscosity with temperature for both water and mercury is applied, and the results are compared with those obtained using the Eyring expressions. As judged by the Gaussian criterion of fit, an expression suggested by the Eyring theory provides smoothed values for the viscosities of both water and mercury which are believed to be more reliable than those in common use. From other empirical equations relating densities and energies of vaporization to temperature, equations are derived for expressing the activation energies for viscous flow as a function of temperature.

From author's summary by William J. Anderson, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 2901, 2915, 2970)

2870. **Müller, W., Motion of an elongated body of revolution in a direction inclined to the longitudinal axis** (in German), *Ing.-Arch.* **20**, 1, 57–66, 1952.

The flow around a body of revolution at incidence is derived in terms of Legendre polynomials from a knowledge of the doublet distribution along the axis. The method is an extension of that discussed for zero incidence in an earlier paper [see AMR 5, Rev. 2082]. G. M. Lilley, England

2871. **Millsaps, K., and Pohlhausen, K., Heat transfer by laminar flow from a rotating plate,** *J. aero. Sci.* **19**, 2, 120–126, Feb. 1952.

An exact solution of the heat-transfer problem for the von Kármán example of the laminar flow of a viscous fluid over a rotating plate is given in dimensionless form and discussed physically. The solution is explicitly given for a constant temperature on the

plate with viscous dissipation included. The numerical results are given for Prandtl numbers from 0.5 to 10.

From authors' summary by Morris W. Rubesin, USA

2872. **Martin, J. C., Moyce, W. J., Penney, W. G., Price, A. T., and Thornhill, C. K., Some gravity wave problems in the motion of perfect liquids. Part I. Penney, W. G., and Price, A. T., The diffraction theory of sea waves and the shelter afforded by breakwaters,** *Phil. Trans. roy. Soc. Lond.* (*A*) **244,** 882, 236–253, Mar. 1952.

The theory employed is that for the irrotational motion of an inviscid incompressible fluid, subject to the boundary conditions of a free, constant-pressure surface, and a uniform depth. It is assumed that the height of the surface waves is small compared with their length, so that linearized forms of the boundary conditions may be used. A solution for the three-dimensional case which has been given by Lamb [sixth ed., Sec. 257] is expressed in terms of a "wave function" $F(x, y)$ of the coordinates in a horizontal plane.

Both rigid and "cushion" types of breakwaters are considered. The equations and boundary conditions for the wave function are identical with those for the diffraction of light by a semi-infinite perfectly reflecting screen, where the two types of breakwaters correspond to different planes of polarization of the incident light. Sommerfeld's solution of the analogous optical problem is then directly applicable.

Wave patterns and wave heights are determined on both the leeward and windward sides of the breakwater for both normal and oblique incidence. The wave patterns in the lee of a small steep-sided island and behind a gap in a breakwater are also discussed. L. Landweber, USA

2873. **de Haller, P., and Bédué, A., The break-away of water columns as a result of negative pressure shocks,** *Sulzer tech. Rev.* no. 4, 18–25, 1951.

Authors show how the problem of the break-away of water columns in discharge pipes as a result of negative pressure waves may be dealt with theoretically. The following assumptions are made: Linearity of the pressure impact and constant gradient of the pipe. The transformation and the motion of the cavity caused by the break-away are studied. The theory is illustrated by the numerical example of a discharge pipe of a pump which suddenly cuts out. L. J. Tison, Belgium

2874. **Birkhoff, G., Plesset, M., and Simmons, N., Wall effects in cavity flow—II,** *Quart. appl. Math.* **9,** 4, 413–421, Jan. 1952.

Authors consider the two-dimensional, irrotational flow of an ideal, incompressible fluid about finite, tandem lamina situated normal to the flow direction, the lamina being connected by free streamlines (constant pressure). Thus, using conformal mapping methods, solutions are obtained for cavity flows with finite cavitation numbers for this model (Riabouchinsky model) in an infinite fluid, in a straight-sided channel of finite width, and in a free jet of finite width. Expressions are obtained for cavity dimensions and drag coefficients. As the lamina are separated indefinitely, solutions are shown to coincide with results derived in part I [AMR **4,** Rev. 2562] for the infinite cavity between the same types of boundaries.

Results will be of much practical interest in the design of water tunnels for studies of finite cavities of very small cavitation number, it being shown that the wall effects are much less severe with free jets than with rigid boundaries. Moreover, for a given cavitation number, there is a limiting value of the ratio of lamina width to rigid-channel width which cannot be exceeded (a "choking" phenomenon). Phillip Eisenberg, USA

2875. **Manwell, A. R., A method of variations for flow problems—II,** *Quart. appl. Math.* **9,** 4, 405–412, Jan. 1952.

This is an extension of author's earlier work [AMR **4,** Rev. 1235]. The main principle is: If a functional of the geometry of an airfoil and its fluid velocities is maximized by a certain profile shape, the functional is stationary for all variations from this shape that vary both coordinates and velocities infinitesimally. A new proof is given for this lemma, and then general formulas for its application to plane incompressible ideal-fluid flow are derived. These are applied to the problem of minimizing $IA^{-1/2}$ where A is the area enclosed by the profile C, and I is any integral of the form $_C\int F(v)ds$, v being the fluid speed. It is shown how the method handles problems involving auxiliary restrictions. In general, the result is obtained in an integrodifferential equation. Finally, it is pointed out that the theory, worked out here in a form suitable for airfoil problems, actually applies as well to minimal problems in other branches of potential theory. An electrical problem is solved as an example. W. R. Sears, USA

Compressible Flow, Gas Dynamics

(See also Revs. 2903, 2906, 2917, 2924, 2930, 2931)

2876. **Carrière, P., Slightly varied supersonic flows** (in French), *Actes Coll. inter. Mécan.* **II,** *Publ. sci. tech. Min. Air, Paris,* no. 250, 197–215, 1951.

Reviewer's half linear method of supersonic flows past slightly inclined bodies of revolution [see R. Sauer, AMR **4,** Rev. 4217] is generalized and simplified by use of epicycloidal coordinates. Special cases are the classic linear methods of von Kármán, Tsien, and others. The essential ideas and the applications discussed in the present article were communicated earlier in a very short previous paper [see AMR **3,** Rev. 1327].

Robert Sauer, Germany

2877. **Viaud, L., Some problems of supersonic aerodynamics in propulsion machines** (in French), *Actes Coll. inter. Mécan.* **I,** *Publ. sci. tech. Min. Air, Paris,* no. 248, 99–111, 1951.

Brief discussions of (1) rocket nozzles and (2) supersonic diffusers (intakes). The first is a simple one-dimensional equilibrium treatment, assuming heat liberated by combustion to be given. The second presents calculations for single- and multiple-shock diffusers, for plane and axisymmetric flow, and compares fixed and variable configurations over a range of Mach numbers.

W. R. Sears, USA

2878. **Young, G. B. W., and Siska, C. P., Supersonic flow around cones at large yaw,** *J. aero. Sci.* **19,** 2, 111–119, 142, Feb. 1952.

Kopal's tables for cones with yaw are given in terms of the independent variable for the zero-yaw case. The present paper gives an approximate method by which the coordinate used by Kopal can be converted to that in the case with yaw for evaluating the data off the cone surface. Theoretical results are then compared with experiments. Regarding the expression "at large yaw" in the title, one must keep in mind that the procedure used is a perturbation method based on an expansion with respect to the angle of yaw. Hideo Yoshihara, USA

2879. **Coffin, J. G., Introduction to shock wave theory,** Fairchild Publ. Fund Paper, Inst. aero. Sci., 63 pp., tables, 1947.

Monograph surveys not only normal and oblique shock waves, but also thermodynamic fundamentals, one-dimensional isentrop-

ic flow, and Prandtl-Meyer expansion theory. Author accomplishes aim of giving a simple review of essential fundamentals. Thus, treatment falls midway between complete textbook development and handbook presentation of *NACA TN* 1428.

Novel approach is choice of relative temperature rise at stagnation, $\Delta T/T = \frac{1}{2}(\gamma - 1)M^2$, as fundamental variable in place of Mach number M. Reasons for change do not seem compelling to reviewer. Many formulas are given with adiabatic index γ (author's k) replaced by 7/5; author states that general results can be recovered by replacing 5 by $2/(\gamma - 1)$, etc., and reviewer is surprised to find that this apparently dangerous process seldom, if ever, leads to ambiguity. Milton D. van Dyke, USA

2880. **Chu, B.-T., On weak interaction of strong shock and Mach waves generated downstream of the shock,** Fairchild Publ. Fund, Inst. aero. Sci., Prepr. 357, 54 pp., 8 figs., 1952.

Consider the supersonic flow over an infinite wedge with straight sides and straight attached nose shock. Present paper investigates changes in this flow due to small deviations in wedge shape. With assumption that perturbed flow is in the neighborhood of original flow, the basic equations (which include effects of entropy change) are linearized. An exact solution of these equations is found which fulfills proper initial values along the shock and fulfills the boundary condition along the wedge surface. Results are used to study interaction of a Mach wave generated at surface of wedge with shock.

Hideo Yoshihara, USA

2881. **Polachek, H., and Seeger, R. J., On shock-wave phenomena; refraction of shock waves at a gaseous interface,** *Phys. Rev.* (2) **84,** 5, 922–929, Dec. 1951.

Problem of the refraction of shock waves at a gaseous interface can be treated by an analysis quite similar to the known three-shock-wave theory. By addition of a gaseous interface, the algebraic complexity and the number of independent parameters are still greater, so that it is only possible to gain a survey by extensive numerical calculations, which were effected on the IBM Selective Sequence Electronic Calculator. The solutions, which represent a three-wave configuration at the interface with the reflected shock wave or with a reflected rarefaction wave, are believed to be physically real inasmuch as they tie in with the two known limiting solutions of an infinitesimal shock at any angle of incidence and of any finite shock at normal incidence. An interesting special solution is given by the "transition" solution, where the strength of the reflected shock wave is zero. Any transition between a refraction pattern of the reflected shock variety to that with a reflected rarefaction must take place at this angle. Two of the significant features of the present solutions are: (1) Regular refraction (three-wave configuration at the interface) does not occur at glancing incidence; and (2) in the region of regular refraction there is no "total reflection" of finite shock waves. The present paper gives only typical examples, the complete results being given in detail in a U. S. Naval Ordnance Laboratory report. Walter Wuest, Germany

2882. **Kistiakowsky, G. B., Density measurements in gaseous detonation waves,** *J. chem. Phys.* **19,** 12, 1611–1612, Dec. 1951.

Time variation of soft x-ray absorption by detonation gases was observed at a fixed station with resolution in time of about 1 μ sec. Mixtures of oxygen, acetylene, and methyl bromide were used. Advantages of this method of investigating structure of detonation wave are described. Author concludes that shock and Chapman-Jouget plane are separated by less than a millimeter.

Bruce L. Hicks, USA

2883. **Roumieu, C., Investigation of critical plane jets** (in French), *C. R. Acad. Sci. Paris* **234,** 1, 52–54, Jan. 1952.

Article sets up an equation of finite differences which represents an approximation to the equation of compressible fluids. Application is made to the critical plane jet, starting with Tricomi's approximate equation and with the exact equation.

From author's summary by Gunther Graetzer, USA

2884. **Pai, S. I., On supersonic flow of a two-dimensional jet in uniform stream,** *J. aero. Sci.* **19,** 1, 61–65, Jan. 1952.

Paper investigates whether supersonic gas jet, discharging into an external medium flowing in same direction as jet, has a periodic structure; i.e., whether velocity potential is a periodic function, as is well known to be the case if jet discharges into motionless external medium with only small difference of pressure between jet and medium. Analysis, based on method of small perturbations (as was Prandtl's for motionless medium), indicates that, if velocity of external flow is subsonic, structure is, in general, *almost* periodic; if velocity of external flow is supersonic, structure is not periodic. Few experimental data are yet available. Formulas are also derived for transmission factor (ratio of magnitude of disturbance in external stream to that in jet) and reflection factor (ratio of magnitude of disturbance reflected from surface of discontinuity to that of incident disturbance), both being functions only of Mach numbers of jet and external stream.

C. W. Smith, USA

2885. **Germain, P., Homographic approximation in the study of compressible fluids** (in French), *Rech. aéro.* no. 25, 9–17, Jan.–Feb. 1952.

The equation for the stream function in the hodograph plane may be written in the form $k(z)u_{xx} + u_{zz} = 0$. Author approximates $k(z)$ by the homographic function $z/(z + a)$ in contrast to the Tricomi approximation $k(z) = Cz$.

Using a simple solution of the equation, author shows that it is possible to construct more general solutions which are valid in the subsonic and transonic regions of flow. These solutions are shown to reduce to those of the Tricomi equation in a limiting case. The numerical computations for particular problems are reserved for a later paper. R. C. Roberts, USA

2886. **Probstein, R., and Charyk, J. V., A method of solving the linear potential equation for axially symmetric flow,** *J. aero. Sci.* **19,** 2, 139–140, Feb. 1952.

Authors' solution uses a polynomial source distribution $f(\xi) = \Sigma_{n=1}^{p} A_n \xi^n$ with coefficients A_n determined by boundary conditions of tangential flow at surface of body. Method is illustrated for flow over parabolic body of revolution using $p = 3$ and compared with results of method of conical segment approximation and Kármán-Moore slender-body theory. No comparison with experiment is made. Lester L. Cronvich, USA

2887. **Lin, C. C., A new variational principle for isenergetic flows,** *Quart. appl. Math.* **9,** 4, 421–423, Jan. 1952.

Author investigates flows without energy dissipation and heat addition for which grad $T_0 = 0$ (T_0 is stagnation temperature). Then $T \operatorname{grad} S + \vec{q} \times \vec{\omega} = 0$ (T temperature, S entropy, $\vec{q}$ velocity vector with components u and v in the directions x and y, $\vec{\omega}$ vorticity vector).

Author starts with the results of an earlier paper [AMR **1**, Rev. 1391], viz., $\delta I = 0$ for the boundary conditions $\psi_n \delta\psi = 0$ in two-dimensional and axially symmetric flows. Herein ψ is stream function defined by $\rho u y^\epsilon = \psi_y$ and $\rho v y^\epsilon = -\psi_x$ (ρ is density;

$\epsilon = 0$ for two-dimensional, $\epsilon = 1$ for axially symmetric flow; suffixes indicate partial differentiations; n = normal) and $I = \int\int (p + \rho q^2) y^\epsilon dx dy$ (p is pressure).

Introducing Crocco's stream function Ψ, defined by $y^\epsilon u(1 - q^2)^{1/(\gamma-1)} = \Psi_y$ and $y^\epsilon v(1 - q^2)^{1/\gamma(-1)} = -\Psi_x$ (γ ratio of specific heats at constant volume and pressure), connected with ψ by the equation $\Psi_\psi = \exp(S/R)$ (R gas constant), so that $\psi_n \delta\psi = 0$ leads to $\Psi_n \delta\Psi = 0$, author shows, that with the latter boundary condition, $\delta I = 0$ leads to Crocco's equation

$$(1 - u^2/c^2)\Psi_{xx} - (2\,uv/c^2)\Psi_{xy} + (1 - v^2/c^2)\Psi_{yy} - \epsilon\Psi_y/y = -y^{2\epsilon}(1 - q^2)^{(\gamma+1)/(\gamma-1)}(1 - q^2/c^2)$$

in which c is velocity of sound. H. Wijker, Holland

2888. **Chang, C.-C., General consideration of problems in compressible flow using the hodograph method,** *NACA TN* 2582, 113 pp., Jan. 1952.

Paper presents a systematic study of the hodograph method as applied to the solution of the differential equations of isentropic steady two-dimensional flow of nonviscous compressible fluids. The scope of the study is best given by the major chapter headings: (1) Canonical and other forms of differential equations in subsonic, transonic, and supersonic regimes; (2) Solutions to canonical forms of approximate differential equations in subsonic, supersonic, and transonic regimes; (3) Different approximations to Chaplygin's differential equations and their solutions; (4) Hypothetical gas law corresponding to approximations of Chaplygin's second equation; (5) Transformation between hodograph plane and physical plane; (6) Flow of compressible fluid through an aperture of a two-dimensional inclined-walled, straight-edged nozzle.

Report includes a most extensive bibliography. Work is a welcome and useful summary of the present state of the art of hodograph methods. H. P. Liepman, USA

2889. **Mirels, H., Estimate of slip effect on compressible laminar-boundary-layer skin friction,** *NACA TN* 2609, 22 pp., Jan. 1952.

A two-dimensional, steady-state solution of the momentum equation for a compressible gas is given by treatment of a related momentum equation for a one-dimensional transient flow originally considered by Rayleigh for incompressible flow, continuum boundary condition, and recently reconsidered by Schaaf [*Univ. Calif., Inst. Engng. Res. Rep.* HE-150-66, 1950] for incompressible flow, slip boundary conditions. Author develops solution for specification $\rho\mu$ = const. The transient solution thus obtained is transformed to the steady-state counterpart by comparison in the continuum flow region with the Chapman-Rubesin [AMR **3**, Rev. 2732] boundary-layer solution. Author's claim that this matching of solutions is essential is not established by comparison with experimental flat-plate drag determinations by Sherman [op. cit., HE-150-70, 1950, and -81, 1951], which data are better represented in the slip flow region by the Rayleigh equations than by the boundary-layer equations of motion.

The analysis given in appendix B is somewhat misleading if not entirely erroneous. In continuum laminar boundary-layer flow, the recovery factor is known to be the square root of the Prandtl number. In the slip flow region, the recovery factor, as defined for continuum flow conditions, is known to increase as a gas is rarefied. It would seem that the parabolic correction to the continuum recovery factor gives the wrong trend for the slip region.

Robert M. Drake, Jr., USA

2890. **Evvard, J. C., and Marcus, L. R., Achievement of continuous wall curvature in design of two-dimensional symmetrical supersonic nozzles,** *NACA TN* 2616, 8 pp., Jan. 1952.

In the design of supersonic nozzles by the method of characteristics, discontinuities of the wall curvature can occur at the geometric point of inflection and at the start of the test section. This condition is especially true of short nozzles, which utilize the maximum expansion angle (half of the Prandtl-Meyer angle) and a very short intial nozzle contour from the throat to the point of inflection of the nozzle.

The characteristic point is defined as that place on the wall where a Mach line of negative slope to the center-line flow direction first assumes the value of the epicycloid constant that occurs in the test section. In order to avoid the discontinuities in the curvature, it is pointed out that the point of inflection should be located upstream of the characteristic point, and that the expansion approaching this point should be gradual. In this manner, the wall curvature will approach gradually its zero value at the point of inflection and at the nozzle exit, and, therefore, the curvature discontinuities will be eliminated at these two points. When these conditions are satisfied, the values of the epicycloid constants are continuous and so are their derivatives with respect to the arc length along a streamline. The nozzle length that results from this type of construction is increased in the arbitrary section upstream of the point of inflection and also downstream of the characteristic point.

Had the authors included a detailed description of the steps taken in their example of the construction of $M = 4$ nozzle, and a scale drawing of the characteristic net, it would have added appreciably to the usefulness of the present report.

Irvine I. Glass, Canada

2891. **Taunt, D. R., and Ward, G. N., Wings of finite aspect ratio at supersonic velocities,** *Aero. Res. Counc. Lond. Rep. Mem.* 2421, 12 pp., Jan. 1946, published 1952.

An error in the well-known work by Schlichting is corrected, and it is shown that the integral equation derived can be solved analytically. The main result of the paper is that, for a plane rectangular wing of aspect ratio A, the lift coefficient is less than that for an infinite plane wing by a factor $1 - {}^1/_2 A(M^2 - 1)^{1/2}$, where M is the Mach number of the undisturbed stream. It is shown that the analytical solution can be extended to plane wings of trapezoidal shape of any cutting-off angle.

From authors' summary

2892. **Miles, J. W., A note on supersonic wing integral equations in unsteady flow,** *Aero. Quart.* **3,** part 4, 294–296, Feb. 1952.

The integral equations are given for the pressure distribution on an oscillating thin wing having a prescribed velocity distribution in supersonic flow, for both supersonic and subsonic trailing edges. In special cases (wings with supersonic leading edge, or rectangular wings of aspect ratio greater than unity), the integral equations may be inverted; however, in general the resulting integrals are intractable. A. W. Babister, Scotland

2893. **Wu, C.-H., A general theory of three-dimensional flow in subsonic and supersonic turbomachines of axial-, radial-, and mixed-flow types,** *NACA TN* 2604, 93 pp., Jan. 1952.

A general theory is presented of steady three-dimensional flow of a nonviscous fluid in subsonic and supersonic turbomachines having arbitrary hub and casing shapes and a finite number of blades. The solution of the three-dimensional direct and inverse problem is obtained by investigating an appropriate combination of flows on relative stream surfaces whose intersections with a z-plane either upstream of or somewhere inside the blade row form a circular arc or a radial line. The equations obtained to describe the fluid flow on these stream surfaces show clearly the several approximations involved in ordinary two-dimensional treatments. They also lead to a solution of the three-dimen-

sional problem in a mathematically two-dimensional manner through iteration. The equation of continuity is combined with the equation of motion in either the tangential or the radial direction through the use of a stream function defined on the surface, and the resulting equation is chosen as the principal equation for such flows. The character of this equation depends on the relative magnitude of the local velocity of sound and a certain combination of velocity components of the fluid. A general method to solve this equation by both hand and high-speed digital machine computations when the equation is elliptic of hyperbolic is described. The theory is applicable to both irrotational and rotational absolute flow at the inlet of the blade row and at both design and off-design operations.

From author's summary by J. F. Manildi, USA

2894. **Hess, R. V., A solution of the Navier-Stokes equation for source and sink flows of a viscous heat-conducting compressible fluid,** *NACA TN* 2630, 60 pp., Feb. 1952.

Equations are solved under condition of constant total flow energy, which occurs when Prandtl number is $^1/_2$ and second viscosity coefficient is equal to the first viscosity coefficient. Two-dimensional source or sink (diverging or converging wedge) flow is emphasized. A nonlinear second-order ordinary differential equation is obtained and solved by a modified isocline method.

Solutions are shown to depend on a single parameter C_2, which is a kind of reciprocal Reynolds number. Nature of the solutions is investigated in detail, including entropy balance and applicability of the Navier-Stokes equations. It is shown that the effect of the (exclusively longitudinal) viscosity and heat-conduction terms is a smoothing-out of the flow discontinuities which exist without these terms. This effect is well known in boundary-layer and one-dimensional shock-flow theory. The viscosity and heat conduction, moreover, may cause a larger mass flow to pass through a given isentropic minimum cross section of a sink flow than for isentropic expansion flow. Consideration of parameter C_2 indicates that the viscosity effects should be negligible for hypersonic tunnels under atmospheric stagnation conditions, even with their usual small minimum sections.

Source flows with heat addition are briefly considered.

Morris Morduchow, USA

2895. **Matthews, C. W., A comparison of the experimental subsonic pressure distributions about several bodies of revolution with pressure distributions computed by means of the linearized theory,** *NACA TN* 2519, 52 pp., Feb. 1952.

Tests were made of two prolate spheroids of fineness ratios 6 and 10, an ogival body, and a prolate spheroid with an annular bump near the nose. Experimental pressures about these bodies are compared with pressures computed by linearized compressible flow theory. Results show that the theoretical methods predict subsonic pressure-coefficient changes over the central portion of the body but do not predict the pressure-coefficient changes near the nose. From author's summary by S. Lampert, USA

2896. **Hamaker, F. M., and Wong, T. J., The similarity law for nonsteady hypersonic flows and requirements for the dynamical similarity of related bodies in free flight,** *NACA TN* 2631, 24 pp., Feb. 1952.

The hypersonic similarity law for steady flow is extended to include nonsteady flows. The aerodynamic forces are correlated by this law, and this correlation is used to derive conditions for dynamical similarity of the motions of related bodies in free flight. The correlation of flight paths was achieved on this basis.

From authors' summary by H. P. Liepman, USA

2897. **Chapman, D. R., and Perkins, E. W., Experimental investigation of the effects of viscosity on the drag and base pressure of bodies of revolution at a Mach number of 1.5,** *NACA Rep.* 1036, 24 pp., 1951.

Models with varying nose shapes, length-to-diameter ratios, and degrees of boat-tailing were tested in a wind tunnel in a range of Reynolds numbers from 0.6×10^6 to 5.0×10^6 (based on model length). Smooth models and models with varying degrees of roughness were used in order to study the effects of both laminar and well-developed turbulent boundary layer, as well as the transition from one to the other. The viscous effects are shown to be quite large and to be dependent on the condition of the boundary layer, the Reynolds number, and the body shape. The flow over the afterbody and the shock pattern in the wake have been analyzed by means of schlieren photographs. The free-drag coefficient, the base pressure, and the total drag are all higher for the case of turbulent boundary layer than for laminar flow at the same Reynolds number. Flow separation usually occurs along the body in laminar flow, and the point of separation varies with the Reynolds number. The flow separation in the boat-tail region is retarded in the case of turbulent flow and usually occurs downstream of the base unless the boat-tail angle is very large. As the Reynolds number varies, the base pressure changes considerably so long as the flow is laminar, but in turbulent flow the base pressure is almost independent of Reynolds number.

The results presented herein were originally published in 1947. Mention is made of a few subsequent similar tests at higher Mach numbers. Ione D. V. Faro, USA

2898. **Borg, S. F., On unsteady nonlinearized conical flow,** *J. aero. Sci.* 19, 2, 85–92, 100, Feb. 1952.

Paper deals with problem of a straight shock striking a symmetrical infinite wedge, ignoring effects of viscosity and conductivity. Equations of continuity and momentum are put into conical form. An invariance property is established and patching-curve relations are derived. Results include also discussion of certain properties of reflected shock; e.g., impossibility of an attached, two-shock pattern for air and of certain combinations of shock strengths and wedge angles. T. Y. Toong, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 2865, 2889, 2930, 2942)

2899. **Sackmann, L.-A., Turbulence in the state of generation** (in French), *Actes Coll. inter. Mécan.* III, *Publ. sci. tech. Min. Air, Paris* no. 251, 221–229, 1951.

Measurements of the fluctuating velocity of flow were made in the transition region using a straight, horizontal tube receiving water from an undisturbed storage tank held at constant pressure and discharging into the air. As the flow changed periodically from laminar to turbulent, the velocity of the jet flowing from the tube varied; this change could be observed by noting the varying horizontal travel of the free jet along its parabolic trajectory. The extremes of velocity were found to correspond closely with calculated values U_L and U_T, assuming either laminar flow according to Poiseuille or turbulent flow according to Blasius, respectively, after appropriate corrections for the loss in pressure at the entrance of the tube.

Defining the probability x of the instantaneous occurrence of fully developed turbulent conditions by the equation $U = xU_T + (1 - x)U_L$, where U represents the observed time-average velocity, it was found that turbulent and laminar flow became equally frequent ($x = 0.5$) at a Reynolds number ($DU\rho/\mu$) of 1165. The transition range extended to and slightly beyond $DU\rho/\mu =$

1407, where $x = 0.9$. Turbulent flow occurred occasionally ($x = 0.4$) at $DU\rho/\mu = 890$ and below. R. L. Pigford, USA

2900. **Burgers, J. M., On a simplified model of turbulence** (in French), *Actes Coll. inter. Mécan.* **III**, *Publ. sci. tech. Min. Air, Paris* no. 251, 261–266, 1951.

Author draws attention to fact that standard practice in turbulence analysis is to take an average of the differential equations governing the motion. This practice encounters difficulties and it would be more desirable, if it were possible, to evaluate directly the average of the solutions. Author suggests that it might be possible to calculate the average, for a suitable ensemble of initial conditions, of the solutions of the simplified equation of motion which he has examined in earlier papers, viz., $\partial v/\partial t + v(\partial v/\partial y) = \nu(\partial^2 v/\partial y^2)$. Solutions of this equation which might be used for this purpose consist of a set of parallel linear segments described by $\partial v/\partial y = t^{-1}$, joined by nearly vertical segments, the whole curve looking like a saw with teeth of different height; the average would be taken with respect to a suitable initial probability distribution of the parameter governing the length of the saw teeth. Author shows that certain simple results obtained by averaging the equations, e.g., the invariance of the first term of the expansion of the spectrum function as a power series in the wave number, can be obtained by averaging the above solutions. He suggests, further, that less direct results, such as the $(-5/3)$-power law of the spectrum, might be obtained by averaging the solutions of his simplified model, although this seems doubtful to the reviewer in view of the known close connection between the reasoning of the Kolmogoroff similarity theory and the number of dimensions of the physical space.

Altogether, a stimulating paper.

G. K. Batchelor, England

2901. **Szablewski, W., Turbulent flow in convergent channels** (in German), *Ing.-Arch.* **20**, 1, 37–45, 1952.

In a previous paper [AMR **4**, Rev. 3645] author integrated the differential equation for fully developed turbulent flow in a pipe using the Prandtl mixing-length relations. In present paper, the same ideas are used to obtain the flow relations in converging channels of very small angle. Empirical coefficients in the logarithmic velocity law, used to approximate the flow in the fully turbulent region, are taken from measurements of Nikuradse. Results then obtained for velocity profiles, shearing stresses, and boundary-layer thickness show good agreement with Nikuradse's measurements in converging channels [*VDI Forschung* **289**, 1929]. Phillip Eisenberg, USA

2902. **Rott, N., and Crabtree, L. F., Simplified laminar boundary-layer calculations for bodies of revolution and for yawed wings,** Fairchild Publ. Fund, Inst. aero. Sci. Prepr. 359, 56 pp., 1952.

According to Thwaites' treatment [AMR **4**, Rev. 355], the two-dimensional incompressible laminar boundary-layer calculation is reduced to a simple quadrature using a one-parameter family of boundary-layer profiles. This method is extended to bodies of revolution. In agreement with the Mangler transformation [AMR **3**, Rev. 1138] for axial symmetrical boundary layers, the momentum thickness θx is obtained by the formula

$$\theta_x^2 = 0.45\nu r^{-2}U^{-6}\int_0^x r^2U^5dx$$

where r is the radius of the body and U the potential-flow velocity.

For yawed infinite cylinders, authors resume the Pohlhausen method of Wild [AMR **2**, Rev. 510]. Under the basic assumption that the chordwise flow is independent of the spanwise flow, the spanwise velocity profiles are of the flat-plate type and only different in scale. This is in good agreement with more exact results of Cooke [AMR 4, Rev. 764]. The integration of the momentum equation for the spanwise flow is finally reduced to a simple quadrature formula for the spanwise momentum thickness

$$\theta_y^2 = \frac{\theta_x^2}{U}\left[0.45\,\nu\,\frac{3}{4}\int_0^x \left(\frac{U}{\theta}\right)^{1/2} dx\right]^{2/3}$$

where θ_x is the known chordwise momentum thickness. The procedure is illustrated for the yawed circular cylinder.

The case of compressible flow is transformed in the incompressible case under certain assumptions by a transformation taken from Illingworth [AMR **3**, Rev. 2420] and Stewartson [AMR 3, Rev. 2019]. Formulas for θ_x in the compressible two-dimensional and axial symmetrical case are obtained, which are not more complicated than those for incompressible flow. Their application to the yawed cylinder is not possible.

Finally, critical comparison is made between the approximate methods for laminar and turbulent layers. For the turbulent boundary layer on a yawed cylinder, the independence theorem of the chordwise and spanwise flow cannot be retained in the same manner as for laminar flow. N. Scholz, Germany

2903. **Van Driest, E. R., Investigation of laminar boundary layer in compressible fluids using the Crocco method,** *NACA TN* 2597, 78 pp., Jan. 1952.

Crocco's method, used in the report to calculate the boundary layer on a flat plate, transforms momentum and energy equations by use of location along plate and velocity parallel to it as independent, and shear stress and enthalpy as dependent variables. This is useful since Crocco showed that, for Prandtl numbers not far from unity, relation between enthalpy and velocity is practically independent of special law for variation of viscosity and conductivity with temperature. It can be considered as universal and tabulated. Then, only a single equation connecting shear stress with velocity remains to be solved. This is carried out for gas with constant Prandtl number equal to 0.75 (Prandtl) constant specific heat, and viscosity varying according to Sutherland's formula. Resulting skin friction and dimensionless heat-transfer coefficients, as well as shear-, velocity-, Mach-number, and temperature profiles through boundary layer are plotted for onstream Mach numbers 0, 4, 8, 16, 20, and wall-to-stream-temperature ratios 0.25, 1, 2, 4, 6, and for insulated wall.

E. R. G. Eckert, USA

2904. **Libby, P. A., Kaufman, L., and Harrington, R. P., An experimental investigation of the isothermal boundary layer on a porous flat plate,** *J. aero. Sci.* **19**, 2, 127–134, Feb. 1952.

Measurements of the velocity profiles on a plate made from sintered bronze with homogeneous suction or injection prove the correctness of corresponding theories by various authors. The transition Reynolds number R_{xtr} tends to infinity if suction corresponding to the theoretical value of approximately $v_\infty = -10^{-4}U$ is applied, where U is free-stream velocity. (Reviewer thinks that the results of Fig. 10 can be approximated by $R_{xtr}/R_{xtr}(v_0 = 0) = (1 + v_0/v_\infty)^{-1/4}$, where v_0 is velocity through the wall, positive for injection, negative for suction, and $v_0 > v_\infty = -10^{-4}U$.) K. Wieghardt, England

2905. **Rawcliffe, A. G., Suction-slot ducting design,** *Aero. Res. Counc. Lond. Rep. Mem.* 2580, 14 pp., Apr. 1947, published 1952.

Maximum efficiency of the suction for boundary-layer control

depends upon maintaining the suction-quantity distribution in the slot nearly proportional to the wing chord along the span of the wing. The power which is needed for the suction is partly given by the pressure losses in the slot and in the suction duct in the wing. The present investigations have tried to find forms of suction slots and ducts with a minimum of pressure loss and a uniform rectangular suction distribution (rectangular wing) through the slot along the span of the wing.

Three forms of suction slots and six forms of ducts have been investigated. Recommendations are formulated for the design of ducting of high efficiency and good local and general distribution. Investigations were confined to suction from still air.

B. Regenscheit, Germany

2906. **Eckert, H. U., Simplified treatment of the turbulent boundary layer along a cylinder in compressible flow,** *J. aero. Sci.* **19,** 1, 23–28, 38, Jan. 1952.

Author extends an earlier paper for flat plate [AMR **4**, Rev. 344] to turbulent boundary layer along a cylinder. Assumptions of earlier paper are retained: seventh-power velocity distribution and Blasius law for skin friction variation with boundary-layer thickness. Author finds full thickness and displacement are less than on flat plate, while momentum thickness and local and mean friction coefficients are higher. Morris W. Rubesin, USA

2907. **Mattioli, E., Relations between the correlation functions of the velocity in homogeneous and isotropic turbulence** (in Italian), *Atti Accad. naz. Lincei R. C. Sci. Fis. Mat. Nat.* (8) **11**, 5, 260–264, Nov. 1951.

Following Prandtl's suggestion ["Strömungslehre," Braunschweig, 1949], von Kármán's equation and the two von Kármán-Howarth equations are derived.

M. J. Goglia, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 2774, 2892, 2896, 2919, 2920, 2922)

2908. **Flax, A. H., and Goland, L., Dynamic effects in rotor blade bending,** *J. aero. Sci.* **18,** 12, 813–829, Dec. 1951.

Common methods of estimating rotor-blade bending moments are based on simple, undamped, single-degree-of-freedom analysis. However, they become of doubtful value when applied to blades which are near, or especially in resonance with one of the periodic aerodynamic forcing functions. This study considers the additional inertia and aerodynamic damping forces due to blade-bending deflection. Their influence on magnitude of stresses developed and on phase lag is shown. Two practical methods of analysis are worked out: One, a simple approximation, uses amplification factors on static bending moment of the blade. The second is a tabular solution of differential equation. Comparison of results obtained by both methods for a typical case indicates fairly good agreement. W. Z. Stepniewski, USA

2909. **Fitzwilliams, O. L. L., The giant helicopter,** *J. Helicop. Assn.* **5,** 4, 391–411, Jan./Feb./Mar. 1952.

How large can a helicopter be and still be economically practical? The author has shown a new approach to this problem by using turbojet engines mounted in the tips of the rotor blades. By this system he proposes a 100-ton gross weight helicopter with seats for 450 troops for a 210-mile range. Preliminary performance and weight estimates are given for smaller versions. Proposals for and discussions of the various Armstrong-Siddeley "Adder" and "Sapphire" gas-turbine engine installations are given. Of these he suggests that the spanwise installation of a Sapphire engine in each blade tip would be less difficult to accomplish. Raymond A. Young, USA

2910. **Seckel, E., Correlation of some longitudinal dynamic stability characteristics of a Bell helicopter from theory and flight tests,** Fairchild Publ. Fund, Inst. aero. Sci. Prepr. no. 356, 20 pp., Feb. 1952.

Paper describes a comparison between flight measurements of the long-period longitudinal dynamic stability of a Bell H-13 helicopter with theoretically computed characteristics. The discrepancy between the measured and calculated long-period oscillation is attributed to an inability to satisfactorily evaluate the important fuselage moment derivatives for use in the theory. Although such is probably the case, a valid check of the assumptions underlying the equations of motions themselves might have been obtained if the measured combined rotor and fuselage derivatives had been used instead of calculated rotor derivatives and flight-estimated fuselage derivatives. Alfred Gessow, USA

2911. **Phillips, W. H., and Kraft, C. C., Jr., Theoretical study of some methods for increasing the smoothness of flight through rough air,** *NACA TN* 2416, 96 pp., July 1951.

Paper is theoretical study of means for reducing accelerations of an airplane due to gusty air from the point of view of passenger comfort. Method of analysis consists in studying the response of the airplane to sinusoidal gust disturbances of various frequencies, using classical airplane-stability theory and operational mathematics techniques. Limitations of the analysis are discussed.

Control motions analyzed for reducing accelerations due to gusts are those of the elevator, the wing flaps, and the elevator and flaps in combination. The desired objective is accomplished most simply by automatically controlled motion of modified wing flaps. Airplane response is studied for such flaps operated according to indications of an angle-of-attack vane or an accelerometer. Calculations are made for a typical modern transport airplane.

Finally, the effect of interconnecting the flap-operating mechanism with the pilot's control is analyzed for its effects on static and dynamic stability and response to control deflection.

Lester L. Cronvich, USA

2912. **Marshall, W. S. D., The distribution of pressure over the surface of wings of small aspect ratio,** *Coll. aero. Cranfield Rep.* 52, 13 pp., 24 figs., Feb. 1952.

The distributions of pressure over wings of aspect ratio 1.5 and 0.5 have been measured for a range of incidence up to and including the stall at various angles of yaw. This report presents a detailed analysis of the results at two incidences corresponding to approximately $^1/_4$ and $^3/_4$ of the stalling incidences. Direct measurements of lift and pitching moment have also been made, and the results compared with the results of theory and previous experiments.

The analysis shows that: (1) Regions of high suctions near the tips assume greater importance as the aspect ratio is reduced. This tip suction rapidly increases in intensity with increase in incidence. (2) Apart from regions near the tips, the spanwise distribution of load becomes more nearly elliptical with decrease in aspect ratio. (3) The effect of a positive sideslip is to skew the spanwise-load grading curve and to produce a negative rolling moment. This effect is more pronounced at small aspect ratios. (4) Comparison between the lift coefficients obtained by direct measurement and from the pressure distributions shows reasonable agreement, and the variations of lift-curve-slope with change in aspect ratio are in agreement with the results of other workers.

Further, a theoretical curve due to Wieghardt shows close agreement with the present experimental values. (5) The method developed by Flax and Lawrence, based on a modified slender-body theory, for estimating the position of the aerodynamic center is found to be in reasonable agreement with the experimental results.

From author's summary by M. J. Thompson, USA

2913. **Trienes, H., and Truckenbrodt, E., Systematic downwash measurements on sweptback wings** (in German), *Ing.-Arch.* 20, 1, 26–36, 1952.

The measurements, now published, were made in 1944/1945 with the same systematic series of wing forms as investigated by W. Jacobs [see AMR **4**, Revs. 4257, 4258] in the 1.2-m tunnel at the Aerodynamical Institute in Braunschweig. Downwash was measured by a method called "Fühlflächen-methode," described by authors. Results show that the contribution of elevators to the pitching stability increases with backward-sweep angle (decreasing with increasing forward-sweep angle), if elevator has invariant distance behind geometrical neutral point.

Comparison with given theoretical calculation is satisfactory for small sweep angles only. Difference increases with sweep angle and reaches about 20% of measured downwash angle for 45° sweep angle. Friedrich Keune, Sweden

2914. **Schlichting, H., Calculation of the influence of a body on the position of the aerodynamic centre of aircraft with sweptback wings,** *Aero. Res. Counc. Lond. Rep. Mem.* 2582, 13 pp., Mar. 1947, published 1952.

Paper presents a theoretical method in which the pitching moment caused by wing-fuselage interference is considered to be made up of two parts—one which is due to the reduction of lift on the wing, and one which is due to the lift on the fuselage. Calculations performed by the method are in good agreement with experiments. F. W. Diederich, USA

2915. **van Heemert, A., Theory of the calculation of load-distribution for yawed and swept wings in incompressible flow,** *Nat. LuchtLab. Amsterdam Rap.* F.91, 35 pp., Aug. 1951.

Paper continues previous work by the author [AMR **4**, Revs. 3668, 3956, 4208, 4209, 4210]. The series development for the vorticity distribution along the chord is cropped, and certain integral quantities appear instead. These are the integral of the vorticity over the chord $\Gamma(y)$, and first and higher moments of the chordwise vorticity distribution. The method is less cumbersome to apply than that previously given by the author; it is not believed to be accurate near the midchord of swept wings.

B. Etkin, Canada

2916. **Loughborough, D. L., The physics of the mechanical removal of ice from aircraft,** *Aero. Engng. Rev.* **11**, 2, 29–34, Feb. 1952.

Measurements of the work of adhesion of ice to rubber are given. Approximate values of adhesive force are used to demonstrate how deicers may be improved through use of smaller radius tubes. The effectiveness of silicone treatment of the deicer is shown to be caused by successive removals of the silicone film. After 25 removals, the effectiveness of the silicone is not measurable. Myron Tribus, USA

2917. **Alden, H. L., and Schindel, L. H., The lift, rolling moment, and pitching moment on wings in nonuniform supersonic flow,** *J. aero. Sci.* **19**, 1, 7–14, Jan. 1952.

Using the linearized theory, report gives simple method for computing lift, rolling moment, and pitching moment for wings and tail surfaces in a stream with a spanwise variation of upwash velocity. The increment in lift is found due to a representative element of the upwash velocity, giving the influence function for lift. Total lift can then be found by a simple spanwise integration.

It is shown that the influence function for lift is the same as the span loading of the wing in reverse flow, and a general formula is given for trapezoidal wings with supersonic leading and trailing edges. In general, this method gives the correct total lift but an incorrect spanwise loading.

Similar influence functions are determined for the rolling and pitching moments. It is shown that it is possible for different distributions of downwash to produce the same total lift but different pitching moments, due to chordwise shift of the center of pressure. A. W. Babister, Scotland

2918. **Whittley, D. C., The rate of climb of turbo-jet aircraft,** *Aircr. Engng.* **24**, 276, 45–47, Feb. 1952.

Paper deals with what appears to be an extremely practical method for the execution of flight tests for the determination of the climbing performance of turbojet aircraft. Method has the advantage of not requiring a rigid program to be followed by the test pilot during the test flights. The procedures for reducing the data to standard conditions are outlined in a simple manner.

M. J. Thompson, USA

Aeroelasticity (Flutter, Divergence, etc.)

2919. **Plantin, C. P., The technique of resonance testing and flutter calculations as applied to fighter aircraft design,** *J. roy. Aero. Soc.* **56**, 494, 117–138, Feb. 1952.

Paper summarizes elements of flutter theory and practice, and points out inadequacy of older simplified criteria for modern high airplane velocities. No original contributions or advanced theory are included, and consideration is restricted chiefly to "classical" flutter. Author believes that, in addition to flutter calculations during design stage, ground resonance tests on prototype airplane are essential (adequate model tests would require practically a full-size model) for determining resonant frequencies and modes of vibration to serve as basis of a complete final flutter calculation and careful flight tests. Technique of making and interpreting such ground tests is described in some detail.

C. W. Smith, USA

2920. **Mazelsky, B., Determination of indicial lift and moment of a two-dimensional pitching airfoil at subsonic Mach numbers from oscillatory coefficients with numerical calculations for a Mach number of 0.7,** *NACA TN* 2613, 30 pp., Feb. 1952.

An extension of *NACA TN* 2562 [AMR **5**, Rev. 2699] for the case of a pitching flat plate in subsonic flow. For incompressible flow, a pitching wing has the same indicial lift as a sinking wing if the angle of attack is defined as that at the $^3/_4$-chord location. This is due to the impulsive nature of the apparent mass effect for any sudden motion in incompressible flow.

However, in subsonic flow the so-called apparent mass concept is not directly applicable since the finite speed of sound produces a nonimpulsive reaction. This produced a finite time-dependent force increment which was found to decay to a negligible value after the airfoil had traveled approximately two chord lengths at $M = 0.7$.

Reviewer believes that the apparent mass effect, which now corresponds to an irreversible nonimpulsive finite rate of energy loss, is, for all practical purposes, time-dependent only in the range of less than $(M/1 - M)$ chord lengths traveled. Beyond this range one can use the indicial lift for a sinking wing, with the

angle of attack measured at the $^3/_4$-chord, for all the lift acting on a pitching wing, and for the moment simply add the constant incompressible apparent-mass value divided by $(1 - M^2)^{1/2}$.

Reviewer also believes the numerical values given are slightly in error because the reciprocal relations used are not exact (see Eq. 21 of "Theodorsen's circulation function for generalized motion," AMR **5**, Rev. 2701), for the exact reciprocal relation.

E. V. Laitone, USA

2921. Runyan, H. L., Cunningham, H. J., and Watkins, C. E., Theoretical investigation of several types of single-degree-of-freedom flutter, *J. aero. Sci.* **19,** 2, 101–110, 126, Feb. 1952.

Brief history of the problem of undamped oscillation of an airfoil with one degree of freedom is given, followed by a discussion of salient points of theory and effects of certain ranges of basic parameters, as shown from numerical work extended by the authors. Graphs are given for a few cases. Each case considered is a limiting one involving two or more degrees of freedom, but no effort is made to consider relaxing of infinite structural stiffness in other degrees of freedom. Authors believe present-day configurations of airplanes at high speeds at high altitudes may prove importance of single-degree-of-freedom studies in relation to both dynamic stability and flutter problems.

Specific problems dealt with are: (A) Subsonic: Pitching of an unswept wing; oscillation of an aileron about its hinge axis; and bending of a swept wing. (B) Supersonic: Pitching of an unswept rectangular wing; pitching of a delta or triangular wing; and oscillation of an aileron about its hinge axis.

Lowell D. Gregory, USA

2922. Barnes, R. H., An analysis of the effect of a power-boost system on wing-torsion control-rotation flutter, Fairchild Publ. Fund, Inst. aero. Sci. Prepr. 354, 15 pp., 7 figs., 1952.

A study of the effect of power-boost system on wing-torsion, control-rotation flutter is presented. A large part of the paper is used to derive equations for handling the flutter part of the problem. The author appears uninformed about the current state of the art of flutter analysis in industry in his derivation. The servo characteristics are defined in an equally elementary manner. The results presented in this paper are, however, of merit since the author has recognized the importance of the aeroelastic power-control-system stability problem. His most important conclusion is that there is a possibility that structural feedback will influence the flutter characteristics when a power-boost control system is employed. John E. Stevens, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2893, 2908)

2923. Bonasse, H., Periodic phenomena by evolution. Hydraulic ram. Reeds acting in water (in French), *Chaleur Industrie* **33,** 318, 319; 3–16, 51–64; Jan., Feb. 1952.

In this hitherto unpublished memoir of his lectures, author analyzes the hydraulic ram, not to improve it but as an instructive example to show how its complicated operation may be divided into simplified individual problems of the corresponding consecutive phases of operation, and, after their clarification, connected to explain the whole machine. (This is the meaning of "by evolution" in the title.) He points out why the 1023 unsystematic experiments of Eytelwein are practically useless and the empirical formulas of his French translator Morin meaningless. Starting with the transformation of the potential energy of water in the lower reservoir into kinetic energy, the velocities, flow rates, energy, and efficiency of this phase are determined as function of time, elevations, and dimensions in suitable parameters. Then, the waste valve opening and closure and factors making them possible and influencing their duration are discussed, followed by treating another phase of the ram operation as an air compressor. Finally, the action of the discharge valve and its interconnection with the former phases of operation lead to an explanation of the factors affecting the relative time taken by these during a complete cycle, the duration of the cycle, the number of cycles per minute, and the ram efficiency.

While appreciating the author's instructive development and discussion of the correlations with a number of novel deductions, one misses the fundamental additions of O'Brien and Gosline ["The hydraulic ram," Univ. Calif. Publ. in Engng. **3,** 1933]. Following a similar subdivision of the cycle of operation, they calculated the number of pressure surges during the period of discharge back and forth from the discharge valve to the supply tank, and the corresponding reduction of the maximum velocity in the drive line to a "recoil velocity" which produces the author's "tension" and makes the opening of the waste valve possible, proving their theory by oscillograms for greatly varying conditions of an experimental ram. Aladar Hollander, USA

2924. Stanitz, J. D., One-dimensional compressible flow in vaneless diffusers of radial- and mixed-flow centrifugal compressors, including effects of friction, heat transfer and area change, *NACA TN* 2610, 61 pp., Feb. 1952.

Theoretical investigation of design problems associated with vaneless diffusers is made, neglecting mixing losses at diffuser inlet, boundary-layer displacement thickness, and flow separation. Fundamental relationships applied include continuity, meridional equilibrium, tangential equilibrium, heat transfer, and equation of state. After combination, the resulting three differential equations with three unknowns are solved by numerical methods for specific cases of analysis and design. Results show friction losses are considerable (efficiency low 80's), heat transfer from fluid has effect opposite to friction, greater diffuser wall-spacing is desirable. Reviewer notes absence of experimental results for comparison and evaluation of calculation methods.

Richard G. Folsom, USA

2925. Thwaites, B., A note on the design of ducted fans, *Aero. Quart.* **3,** part 3, 173–181, Nov. 1951.

Based on familiar "strip-theory" (blade-element theory) equations, procedure was developed for design of fan for a given performance and for calculation of performance of a given fan. Paper also analyzes conditions for maximum efficiency for the special case of a constant pressure rise and a constant axial velocity along the radius of the fan. Hsuan Yeh, USA

2926. Wyatt, de M. D., Aerodynamic forces associated with inlets of turbojet installations, Fairchild Publ. Fund, Inst. aero. Sci. Prepr. 340, 12 pp., 6 figs., 1952.

Paper attempts to clarify the confusion which has arisen due to conventional subsonic definitions for thrust and drag of inlets being applied to supersonic flight. Author considers initially the basic pressure forces acting on an inlet when operating under spill conditions, and then relates these forces to the conventional definitions of thrust and drag. It is then shown that, at subsonic speeds, this expression can be reduced to that for net thrust as conventionally defined. However, under supersonic flight conditions no such simplification is possible, but it has been found convenient to define an additional drag term called the additive drag.

The significance of this additive drag is then discussed in detail, and finally, quantitative calculations of the relative magni-

tudes of additive drags associated with spillage for three types of intakes are given. G. C. Quigg, USA

2927. **Delio, G. J., Evaluation of three methods for determining dynamic characteristics of a turbojet engine,** *NACA TN* 2634, 56 pp., Feb. 1952.

Purpose of paper is to provide basis for choice of suitable method of determining engine dynamic characteristics. Transients resulting from approximate step and sinusoidal disturbances of fuel flow are analyzed by three methods: (a) Direct observation of functional relationships from data resulting from approximate step-function input; (b) Fourier analysis of such data; and (c) experimental determination of frequency-response functions using data resulting from sinusoidal disturbances. Fourier transform is used to show essential equivalence of methods. Method (a) yielded basic dynamic characteristics with minimum engine, computation, and equipment operating time, but limitations of instrumentation did not permit it to yield high-frequency characteristics of engine system. With method (b), engine and equipment time were at a minimum, but computing and analysis time were excessive, particularly when high-frequency data were sought. Method (c) yielded the high-frequency characteristics, at the expense of longer engine and equipment operating time and of moderate amount of calculating time.

Joseph V. Foa, USA

Flow and Flight Test Techniques

(See also Revs. 2897, 2910, 2913, 2919)

2928. **Clark, J. A., and Rohsenow, W. M., A new method for determining the static temperature of high-velocity gas stream,** *Trans. ASME* **74,** 2, 219–227, Feb. 1952.

A method and apparatus are described for measuring static temperature of gases flowing at high and low temperatures and at high air velocities. Some experimental data are included. The two important qualities of the instrument and method described are: (1) The instrument indicates a point value of temperature, and (2) the equation describing the temperature is practically independent of the composition of the gas. The device is simple to construct, rugged, and not subject to the effects of corrosion.

George A. Hawkins, USA

2929. **Bird, J. D., Visualization of flow fields by use of a tuft grid technique,** Fairchild Publ. Fund, Inst. aero. Sci., Prepr. 351, 12 pp., 9 figs., 1952.

The qualitative tuft method of exploring flow fields is applied in the form of a uniform grid or matrix of tufts to obtain flow deflections. It appears that quantitative results in steady subsonic flows are obtainable with reasonable accuracy. Downwash, sidewash, development of trailing vortex systems, and effects of angles of attack and sideslip have been measured from photographic records of grid-tuft deflections in the wake and in the flow about several wing planforms. This paper demonstrates how careful application of an elementary technique may yield considerable insight into the nature of complex flows.

H. M. Spivack, USA

2930. **Monaghan, R. J., and Johnson, J. E., The measurement of heat transfer and skin friction at supersonic speeds. Part II. Boundary-layer measurements on a flat plate at $M = 2.5$ and zero heat transfer,** *Aero. Res. Counc. Lond. curr. Pap.* 64, 32 pp., 13 figs., Dec. 1949, published 1952.

Discussion of techniques and results of an experimental investigation of boundary-layer profiles and skin friction. Surveys of the boundary layer along a plate were made with a total-pressure tube, and velocity profiles were calculated by Rayleigh's Pitot-tube formula and measurements of the static pressure on the plate. Rate of growth and displacement and momentum thickness of laminary boundary were found to be greater than predicted by theory, a fact which was attributed to the conditions at the leading edge of the plate. The thickness of the turbulent boundary layer was approximately the same as in low speed flow. A semi-empirical formula for turbulent skin friction, as deduced from the total-pressure tube surveys, is presented; this formula is based upon the fluid properties at the surface. A preliminary investigation was made of chemical methods for indicating transition.

Wallace F. Davis, USA

2931. **Bardsley, O., and Mair, W. A., Separation of the boundary layer at a slightly blunt leading edge in supersonic flow,** *Phil. Mag.* (7) **43,** 338, 344–352, Mar. 1952.

Paper continues work by same authors [AMR **4**, Rev. 3043]. Experiments were performed in an intermittent supersonic wind tunnel at Mach number 1.96 using wedges of apex angles 5° and 10° with thickness t of leading edge varying from 35μ to 200μ. Wedge was placed at a sufficient incidence to yield an expansion region on one side. Schlieren photographs showed a weak shock wave on downstream side of expansion region for values of t greater than about 80μ, corresponding to a Reynolds number R_t, based on thickness of leading edge, of about 1000. Authors conclude that weak shock results from separation and re-attachment of boundary layer for R_t greater than 1000, but there is no separation for values of R_t less than this value.

Charles E. Carver, Jr., USA

Thermodynamics

2932. **Foulkes, P., On a general thermodynamic theory of the equation of state,** *Physica* **17,** 11/12, 943–952, Nov./Dec. 1951.

A general equation of state for a pure fluid in a single phase is derived in the form $v = (T/p)\varphi(p/T^{n+1}) + h(p)$, where φ and h are general functions and n is a constant. This relation is derived using relationships arising from the first law of thermodynamics, Nernst's theorem, and certain extremal properties of the equilibrium state. No particular atomic or molecular model is postulated.

Author shows that Callendar's equation and the expansion of Kammerlingh-Onnes are special cases of the derived equation, but that Van der Waal's equation is not, since the latter violates the conditions of the Nernst theorem.

Reviewer feels that this is a valuable contribution to the theory of thermodynamics. Although the information provided by the derived equation of state is general in character, it provides a systematic means for determining if an equation of state suggested by analysis or experiment is compatible with thermodynamic theory.

Lawrence Talbot, USA

2933. **Majumdar, N. G., Thermodynamics of matter in a static field,** *Bull. Calcutta math. Soc.* **43,** 1, 51–55, Mar. 1951.

Author proves that Tolman's result [Tolman, R. C. "Relativity, thermodynamics and cosmology," p. 313, 1934] for thermodynamic equilibrium of a sphere of perfect fluid in a static gravitational field is independent of the form of the field equations, so long as space is Riemannian.

From author's summary by Irvin M. Krieger, USA

2934. **Traupel, W., Dynamics of real gases** (in German), *Forsch. Geb. Ing.-Wes.* **18**, 1, 3–9, 1952.

For some real gases, such as water, ammonia, and Freon, but not for carbon dioxide except in a limited range, the adiabatic exponent $-(\partial \ln P/\partial \ln V)_s = k$ is substantially independent of pressure, and the compressibility factor $z = pv/RT$ is nearly constant along a line of constant entropy. When these simplifications are possible and when there is no heat transfer, the same dynamical, energy, and continuity equations that are employed to describe the flow of an ideal gas can be used in the high-pressure range for a real gas. The quantity $(k-1)i/kR$ is substituted for absolute temperature in the ideal-gas equations, and $k/(k-1)R$ replaces c_p (i refers to the enthalpy of the gas). Equations for critical velocities in nozzles are also similar to those commonly used. R. L. Pigford, USA

2935. **Lunbeck, R. J., Michels, A., and Wolkers, G. J., Thermodynamic properties of nitrogen as functions of pressure and temperature between 0 and 6000 atmospheres and −125° and +150°C,** *Appl. sci. Res.* (*A*) **3**, 3, 197–210, 1952.

Tables are given for the thermodynamic functions of nitrogen at integral values of pressure up to 6000 atmospheres and temperatures between −125 and +150 C.

From authors' summary

2936. **Manton, J., von Elbe, G., and Lewis, B., Nonisotropic propagation of combustion waves in explosive gas mixtures and the development of cellular flames,** *J. chem. Phys.* **20**, 1, 153–157, Jan. 1952.

Many observations have shown that combustion waves in explosive gas mixtures are often folded or broken even when no external conditions are present to cause this nonisotropic propagation. The theoretical explanation of this phenomenon is sought.

The reported experiments on spherical flames using high-speed schlieren photographs of combustion waves in a spherical bomb, along with other experimental results, show that nonisotropic propagation is characteristic of nonstoichiometric explosive mixtures in which the deficient reactant has the largest diffusivity. These data support the theory that in convex-curved areas of the wave the burning velocity is reduced because the diffusion lines diverge, decreasing the concentration of the constituent with the greatest diffusivity; whereas, the opposite is true in concave-curved areas. The data, therefore, do not support the older theory of hydrodynamic instability of a combustion wave.

Reviewer believes the paper to be an excellent contribution toward a more complete understanding of the fundamental combustion phenomena. Until the fundamental problem is well understood, engineering applications and combustion-chamber design must be largely empirical. Ray E. Bolz, USA

2937. **Emmons, H. W., Harr, J. A., and Strong, P., Thermal flame propagation,** Comput. Lab., Harvard Univ. HUX-9, 22 pp., 7 figs., Feb. 1950.

Exact equation and its solutions are presented for the propagation rate of a highly simplified model of a flame propagating through a combustible mixture. A nonlinear differential equation for propagation by thermal means only, describes temperature as a function of distance normal to the flame front in a frictionless, adiabatic pipe, assuming a single, first-order reaction going to completion, constant fluid properties, and steady, one-dimensional incompressible flow. After stipulating boundary conditions to be an initial temperature and composition on one side of the "flame" and a temperature gradient of zero on the other side, and after suitable transformations of the basic equation, sets of solutions are obtained with the aid of the Mark I calculator. Main contributions of the calculations over the usual approximate solutions of the differential equation are that the low temperature, or heating zone, is described, and the necessity of hypothesizing an ignition temperature is obviated. Main liability of the paper is the greatly simplified model assumed for the flame.

Walter T. Olson, USA

2938. **Shepherd, W. C. F., The ignition of gas mixtures by impulse pressures,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 301–316, 1949. $13.50.

A preliminary study was made of ignition resulting from pressure effects occurring when a body of compressed air is suddenly released into an inflammable gas mixture in a 1-in. diam tube by the rupture of an intervening diaphragm. Methane-oxygen and ethylene-oxygen mixtures were investigated. Both schlieren and direct flame photographs were made of the ignition process using a rotating-drum camera.

The ignition of highly flammable mixtures was shown to be directly caused by the pressure effects from diaphragms bursting at very low pressures. Flame first develops in the main shock wave, leading usually to detonation. There is no measurable ignition lag. For the most explosive mixtures of ethylene and oxygen, the minimum igniting pressure is below 50 psig.

Ignition of weak mixtures is obtained at somewhat higher pressures, but flame does not always becomes established, though this failure may lie in the experimental method. The photographs indicate a possible flow of air from the compressed-air chamber into the inflammable-gas chamber; this would result in a layer of air which might act as a barrier to the transmission of flame, particularly at high bursting pressures.

J. Howard Childs, USA

2939. **Hirschfelder, J. O., and Curtiss, C. F., Theory of propagation of flames. Part I: General equations,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 121–127, 1949. $13.50.

A general theory of laminar one-dimensional flame propagation for premixed homogeneous gases is formulated. The mass flow rate for steady burning is an eigenvalue of the simultaneous solution of the conservation, diffusion, and chemical reaction rate equations. The momentum equation is used only to show that the pressure drop across the flame front is small. The hot boundary conditions are formulated by noting that diffusion currents, temperature gradients, and concentration gradients approach zero asymptotically as the chemical reactions go to completion. The cold boundary conditions are formulated by using a "porous flameholder" whose principal functions are (a) to provide a convenient place at which the unreacted gas mixture is available, and (b) to prevent diffusion of reaction products back to the premixed gases ahead of the flame holder. Details of the solution of the requisite set of equations are described for the single-stage reaction $A \rightarrow bB$. A summary of the conservation and general diffusion equations is given for three-dimensional unsteady flow.

S. S. Penner, USA

2940. **Henkel, M. J., Spaulding, W. P., and Hirschfelder, J. O., Theory of propagation of flames. Part II: Approximate solutions,** Third Symp. Combust. Flame Expl. Phemon.; Baltimore, Md., Williams & Wilkins, 127–135, 1949. $13.50.

Methods for obtaining the mass flow rate M for steady burning are described. An approximate solution leading to an explicit relation for M is given for the unimolecular decomposition $A \rightarrow bB$. The method of approach is characterized by fitting the solution to the hot boundary conditions and then showing that the cold boundary conditions are also satisfied approximately. The

grouping of the parameters in the expression for M is similar to the familiar results obtained by earlier investigators using less general formulations. An explicit relation is obtained also for the thickness of the flame front. The calculated numerical values of M for the decomposition of azomethane are of the correct order of magnitude. The flame equations have also been solved for the reaction $2NO \rightleftarrows N_2 + O_2$ to obtain an explicit relation for M. Since the decomposition of NO is not described by a bimolecular decomposition, the numerical values obtained are to be regarded as rough first-order approximations. S. S. Penner, USA

2941. **Henkel, M. J., Hummel, H., and Spaulding, W. P., Theory of propagation of flames. Part III: Numerical integration,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 135–140, 1949. $13.50.

The flame equations for the unimolecular and bimolecular reactions given in part II are integrated numerically in order to determine the mass flow rate. The results of the numerical calculations show that the solutions obtained in part II constitute reasonable approximations.

Since the publication in 1949 of the preceding two papers reviewed, Hirschfelder and his collaborators have carried out more careful studies of the formulation of the cold boundary conditions. The most recent and most satisfactory discussion of one-dimensional flame propagation is contained in Report No. CM-690 issued by the Naval Research Laboratory of the University of Wisconsin, February 15, 1952. S. S. Penner, USA

2942. **Wohl, K., Gazley, C., and Kapp, N., Diffusion flames,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., William & Wilkins, 288–300, 1949. $13.50.

Authors have made an extensive study of laminar and turbulent diffusion flames rising vertically from a tube into still air. City gas and butane were used with an initial fuel mixture ranging from pure fuel to stoichiometric and flow velocities up to 100 fps. The height of the flame (a measure of the time necessary for combustion) and the structure of the flame were examined by shadow photographs. A theoretical expression for flame height based on a diffusion process is deduced and, by consideration of the nature of the different flame investigated, the basic expression is found to represent the experimental results.

This work is an extension of investigations by Burke and Schumann [*Indust. Engng. Chem.* **29**, 998–1004, 1928] and is in substantial agreement with the recent work of Hottel et al. [AMR **5**, Rev. 2662]. Robert A. Gross, USA

2943. **Markstein, G. H., Interaction of flame propagation and flow disturbances,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 162–167, 1949. $13.50.

Effect of flow disturbances on flame shape and burning velocity of Bunsen flames. High-speed motion pictures were taken of schlieren images of propane-air Bunsen flames disturbed by sound waves, electric fields, and vibrating wires. Qualitative data obtained indicate that burning velocity is constant and independent of the distortion of the flame front. Small-scale disturbances were found to be amplified by flame front. Unexplained inversion occurred in which disturbances first increased, then decreased in amplitude. Author believes that studies of interaction of flame propagation and simplified models of turbulence, such as those described in report, may lead to better understanding of more complicated flow phenomena present in turbulent flames.

Thomas P. Clark, USA

2944. **Evans, Majorie W., Scheer, M. D., Schoen, L. J., and Miller, E. L., A study of high velocity flames developed by grids in tubes,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 168–176, 1949. $13.50.

An experimental method of studying high-velocity flame fronts has been developed by the authors. Flames are developed in long pyrex tubes, closed at one end where ignition takes place. By use of a grid in the path of the flame, combustion processes are accelerated and flame-front velocities are increased, reaching values to 1000 fps. Schlieren photographs of the phenomena have been taken and comparison made with normal flame fronts. The high-velocity fronts are reproducible. Explanation of various effects observed is attempted, and it appears that pressure of the burned gases is responsible for the high-velocity fronts.

H. M. Spivack, USA

2945. **Williams, G. C., Hottel, H. C., and Scurlock, A. C., Flame stabilization and propagation in high velocity gas streams,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 21–40, 1949. $13.50.

Paper presents an excellent experimental study of flame stabilization and propagation associated with bluff bodies in gaseous fuel-air mixtures flowing in a duct. Variables considered are fuel-air ratio for propane and natural gas fuels, entrance gas velocity, flame-stabilizer geometry, turbulence in the entering stream.

Experiments were conducted in a constant cross-section chamber arranged to receive a premixed (gas) fuel-air mixture at atmospheric pressure, variable temperature (340 K maximum), variable velocity (20 to 350 fps), and variable turbulence level (by screens).

The research is comprehensive, and reviewer believes the results very valuable for a clearer understanding of the mechanism of combustion when controlled by aerodynamic phenomena.

A few of the more important results are: (1) No vortex trail shed from a bluff stabilizer during combustion; (2) the influence of approach-stream turbulence on flame velocity is very small compared with the influence of turbulence created downstream of the flame stabilizer by velocity gradients generated across flame front; (3) further explanation of flame stabilization behind bluff objects; (4) correlation expression for blow-out limit data for stabilizer with a characteristic dimension from 0.016 to 0.50 inch; (5) effect of bluff stabilizer shape on stability limits is negligible for those employed. Ray E. Bolz, USA

2946. **Longwell, J. P., Chenevey, J. E., Clark, W. W., and Frost, E. E., Flame stabilization by baffles in a high velocity gas stream,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore Md., Williams & Wilkins, 40–44, 1949. $13.50.

Measurements of the range of air/fuel ratios over which a baffle stabilizes a flame are reported as a function of mixture velocity and baffle diameter. Some effects of baffle shape, mixture temperature, and pressure are noted. Fuel (No. 1 solvent naphtha, consisting of 68% paraffins and 32% naphthenes by volume) was premixed with air and pre-evaporated. Flame stability over a range of air/fuel ratios of approximately 9 to 24 was achieved for mixture velocities up to approximately 800 fps at atmospheric pressure and inlet-air temperature of 300 F. The results are correlated on the basis of the ratio of baffle radius R to mixture velocity V over a range of R/V of from approximately 0.06 to 0.4 millisecs. Antoni K. Oppenheim, USA

2947. **Usui, T., On the thermodynamic equation of motion of the two-fluid model of Helium II,** *Physica* **17**, 7, 694–702, July 1951.

Using the two-fluid model of liquid He II with an assumed fluid

mixture of normal fluid and superfluid, each having different density and velocity of propagation of the second sound, author derives thermostatic (equilibrium) and thermodynamic (non-equilibrium or irreversible) energy relations for reversible and irreversible processes in liquid He II.

The model used for this fluid is the two-velocity model necessary for the two types of sound waves in liquid He II. The equations obtained show the mechanisms contributing to the irreversible entropy production. With assumptions about a "thermostatic model," formulas are obtained for the wave propagation of this fluid mixture. The results have not been tested experimentally, and it may be very difficult to do so because it is necessary to determine the concentration of the normal fluid present as a function of pressure and temperature.

Rohn Truell, USA

2948. **de Groot, S. R., Thermodynamics of irreversible processes (Lecture series no. 13, prepared by G. Newell and D. Bershader)**, Univ. Maryland, Inst. Fluid Dynamics Appl. Math., 44 pp., 1951. $.60.

A brief survey of some of the topics covered in author's book of same title [AMR **5**, Rev. 240] includes proof of Onsager's relation, a discussion of the entropy balance, thermoelectricity, the "two-fluid" model of liquid helium, electrochemical potential, electrokinetic phenomena, and coupled chemical reactions. The appendix is on the hydrodynamical equations and their relation to thermodynamics. There are numerous misprints.

Robert E. Street, USA

Heat and Mass Transfer

(See also Revs. 2859, 2928, 2964)

2949. **Kays, W. M., and London, A. L., Convective heat transfer and flow friction behavior of small cylindrical tubes—circular and rectangular cross sections,** Ann. Meeting ASME, Nov. 1951, Atlantic City. Paper No. 51—A-130, 20 pp., 2 tables, 7 figs.

Heat transfer (condensing steam to warming air) and friction measurements for air flow were made for circular tubes (0.231-in. ID, 18.3 in. long) arranged in a bundle with free-flow-to-frontal-area ratio 0.530, and for rectangular tubes (0.48 × 0.082 in., 8 in. long) arranged in a bundle with free-flow-to-frontal-area ratio 0.396. For the circular tube bank, the recommended friction factor and gas-film heat-transfer coefficients are shown graphically on a plot of f and of $N_{St}(N_{Pr})^{2/3}$ vs. N_{Re}, estimated accuracy $\pm 5\%$ (N_{Re} 500 to 2000; 10,000 to 50,000) and $\pm 15\%$ (10,000 > N_{Re} > 2000); the transition region extends from N_{Re} ca. 2000 to ca. 10,000. For rectangular tubes, length/4 (hydraulic radius) > 25, $N_{St}(N_{Pr})^{2/3} = 0.019\ N_{Re}^{-0.2}$ for turbulent flow, $N_{Re} < 12{,}000$, accuracy $\pm 5\%$, irrespective of aspect ratio. For laminar and transition flow, additional work is to be done to include aspect ratio (f is friction factor, N_{St} dimensionless Stanton number, N_{Pr} Prandtl number, N_{Re} Reynolds number).

Robert E. Treybal, USA

2950. **Madden, A. J., Jr., and Piret, E. L., Heat transfer from wires to gases at sub-atmospheric pressures under natural convection conditions,** Gener. discuss. heat transf., Lond. Conf., Sept. 11–13, 1951, Sect IV. London, Instn. mech. Engrs.; New York, Amer. Soc. mech. Engrs., 6 pp., 1951.

This excellent paper treats the important subject of heat transfer between a solid surface and a gas at subatmospheric pressures. Owing to infrequent molecular impacts at very low pressure, gas molecules approaching a heated surface do not come into equilibrium with molecules rebounding from the surface. The result is a discontinuity in temperature at the gas-solid boundary, sometimes called "temperature jump." To calculate the rate of heat transfer from a solid surface under low pressure conditions, authors have employed the accommodation coefficient which is the ratio of the actual heat-energy exchange at the surface to the theoretical exchange there. A model is set up for analysis, consisting of a small region of one mean free-path thickness adjacent to the surface of a wire where heat transfer is postulated to occur by molecular transport, and an overlying region defined as the gas film through which heat is conducted by the usual mechanism of conduction in a stagnant medium. By equating the heat transfer as expressed by molecular transport from a solid to a gas to that conducted through the film as given by Fourier's law, a dimensionless expression for the Nusselt number is obtained in terms of a modified Prandtl number, gaseous ratio of specific heats, the accommodation coefficient, the film thickness, wire diameter, and mean free-path length. Experimental data are well correlated with the usual free convection parameters of Grashof-Prandtl product for horizontal wires, with diameter-to-heated-length ratio included for vertical wires.

As an interesting sidelight, authors include a table showing the effect of pressure on the heat-transfer coefficient h. To accomplish a reduction in h of 50% from its value at atmospheric pressure, the pressure must be reduced to 1% or 2% of its original value.

John A. Clark, USA

2951. **Chapman, S., Thermal diffusion (Lecture series no. 19)**, Univ. Maryland, Inst. Fluid Dynam. appl. Math., 23 pp., 1952. $.60.

The development which led to the theoretical and experimental discovery of thermal diffusion in gases and liquids (Soret effect) is outlined. The dependence of the thermal diffusion factor on the forces between molecules, their mass and number ratios, and the temperature is discussed. The inverse diffusion thermo-effect also is presented. Applications in the separation of isotopes by the thermal diffusion column of Clusius (not Clausius as in text) and possible effects in the earth's atmosphere and in volcanic dikes are considered.

P. Kriezis, USA

2952. **Takahashi, Y., Transfer function analysis of heat exchange processes,** "Automatic and manual control," New York, Academic Press, 235–245, 1952. $10.

Paper considers heat exchanger as an element in control loop. Author defines transfer function as ratio of "outlet temperature of 'cold' fluid to inlet temperature of 'hot' fluid," when inlet temperature varies as $e^{j\Omega\tau}$. Processes are classified into four cases: (a) Both fluids unmixed; (b) one fluid mixed, other unmixed; (c) both fluids mixed; and (d) percolation (one fluid flowing along a solid surface). Heat capacity of exchanger walls is treated by assuming infinite conductivity in 'ranverse direction, and zero conductivity in longitudinal direction.

Frequency response curves are plotted for above processes, and the application of these curves to a control problem demonstrated. Author states conclusions were verified experimentally in one case.

Reviewer believes paper to be a useful contribution to literature on process control, although author's claim of an exact analysis is doubtful. Paper has some diagrammatic errors.

William A. Wolfe, Canada

2953. **Hogan, C. L., and Sawyer, R. B., The thermal conductivity of metals at high temperature,** *J. appl. Phys.* **23**, 2, 177–180, Feb. 1952.

A modification of the Forbes bar method, which was used to

measure the thermal conductivities of samples of inconel, nickel, various stainless steel alloys, and 1010 steel, is clearly described. A mathematical analysis (assuming constancy of thermal conductivity with temperature) is used to discuss the error involved in neglecting an end effect of the sample. Results are given for a temperature range of 25 C to 1000 C, and also quoted are the electrical conductivities. Results are compared qualitatively with theory given by Wilson [*Proc. Camb. phil. Soc.* **33,** 371, 1937] and Makinson [op. cit., **34,** 474, 1938].

C. J. Tranter, England

2954. **Fowler, R. T., Richardson, D. A., and Rivière, M., Measurement of heat flow** (in French), *Chaleur Industrie* **33,** 318, 17–20, Jan. 1952.

A description is given of the measurement of the flow of heat using an experimental oven in which measurements are made of the radiant energy received by cold bodies at various points in the oven. Results of the calibration of the instrument before and after a series of tests are given. These results show a spread of about 20%, which, in the authors' opinion, is due principally to the calibration measurements and not to fundmental errors in the instrument. C. M. Crain, USA

2955. **Grigull, U., Heat transfer in film condensation** (in German), *Forsch. Geb. Ing.-Wes.* (*B*) **18,** 1, 10–12, 1952.

A simple formula is given for turbulent film condensation on a vertical wall. The laminar-film condensation formula as developed by Nusselt is compared to the turbulent-film condensation formula when both are arranged in dimensionless form. It is shown that the coefficient of heat transfer for laminar film condensation of steam reaches a maximum at 200 C, while for turbulent film condensation the heat-transfer coefficient increases as the saturated vapor pressure increases.

W. L. Sibbitt, USA

Acoustics

(See also Rev. 2787)

2956. **Somerville, T., and Ward, F. L., Investigation of sound diffusion in rooms by means of a model,** *Acustica* **1,** 1, 40–48, 1951.

Diffusion of sound by the walls is known subjectively to be desirable. Authors consider that rectangular recesses or projections in the form of "coffering" tend to produce much more desirable subjective acoustic properties than other forms. The object of the investigation was to develop an index to measure physical effects with the eventual aim to establish a correlation between index and subjective evidence. Measurements of the transmission characteristics between two corners and of the response to a short tone pulse of 1 msec duration were made in a small scale model (121 × 87 × 7 cm³). For the irregularity of the transmission characteristic, the index chosen was: The difference between the length of the record trace and the horizontal distance between two frequency marks. For the amplitude irregularity of the short-pulse displays, three different indexes were used, (1) standard deviation, (2) average percentage deviation, (3) average deviation of the average of quarter sections. The three forms of diffusing elements used were (a) hemi-cylindrical, (b) triangular, (c) rectangular. A significant reduction in irregularity for nearly all diffusing elements is found, the reduction being greatest for the rectangular elements. However, some doubt on the general validity of this way of evaluating a diffusing configuration rises with reviewer, because a small displacement of the plane wall gives nearly the same reduction in irregularity as some diffusing elements. The proposed extension of the same methods to other models and full-scale studios is, therefore, of great value.

R. Vermeulen, Holland

2957. **Wada, Y., and Shimbo, S., Experimental investigation on the origin of the anomalous absorption of ultrasonic waves in liquids,** *J. acoust. Soc. Amer.* **24,** 2, 199–202, Mar. 1952.

There are two classes of liquids which show anomalous absorption of ultrasonic waves, class A1 (nonassociated liquids), and A2 (associated liquids). In mixtures of two liquids of class A1, both density and sound velocity vary almost linearly with concentration, in spite of the anomalous variation of sound absorption. The smaller the ultrasonic absorption of a liquid of class A1, the greater is the decrease of absorption per unit concentration in a dilute benzene solution of the liquid. This does not hold in liquids of class A2, such as alcohols. The inverse correlation between the absorption of ultrasonic waves and infrared radiations was found in the case of liquids of class A1. It was concluded from the above facts that the absorption of ultrasonic waves in nonassociated liquids should be a result of the so-called "molecular absorption," in the same way as in gases. In the case of associated liquids, some part of the absorption is probably ascribed to the molecular absorption, but the remaining part may be caused by another relaxation mechanism, a slow change in local order of molecules. The contribution of the molecularab sorption to that, in highly viscous, is also estimated.

From authors' summary by W. H. Pielemeier, USA

Ballistics, Detonics (Explosions)

(See also Revs. 2882, 2938)

2958. **Sestier, A., A chronophotographic method of recording trajectories of fast devices from a distance of several kilometers** (in French), *Actes Coll. inter. Mécan.* **II,** *Publ. sci. tech. Min. Air, Paris* no. 250, 65–72, 1951.

Author discusses a photographic scheme used successfully for determining trajectories of high-speed aircraft and self-propelled missiles. The method consists essentially of placing a luminous source on the test aircraft or missile and then photographing simultaneously with still cameras from two positions the movement of the light. The trajectory is then deduced from the geometry of the arrangement and measurements made on the two photographs. For cases cited, positions are determinable to about 1 m in 10 km and velocities to about one part in a thousand. Similar photographic schemes have been used for many years by astronomers [*Rev. mod. Phys.* **15,** 4, 246–264, Oct. 1943] for determining trajectories of meteors. J. S. Rinehart, USA

2959. **Rydberg, S., Ballistics for engineers** (in Swedish), *Tekn. Tidskr.* **81,** 46, 1073–1083, Dec. 1951.

Author defines scope of paper as an introduction to ballistics with a qualitative exploration of the main subregions of this field. The first section defines ballistics as the science dealing with the motion and effect of stabilized projectiles, bombs, and rockets, excluding guided missiles and missiles with wings. It mentions the basic concepts and terms, and explains the main problem of ballistics: To predict the trajectory of a projectile or missile fired under specified conditions. During recent years, improved accuracy of the solutions to this problem has been required, partly due to the progress in both automatic computers and in devices for aiming guns.

A section on interior ballistics discusses powder combustion and mentions the basic equations for interior ballistics, i.e., the equation of motion of the projectile, the energy equation, and the

equations describing the powder combustion. The next section deals with exterior ballistics, examining the variables influencing the projectile motion. The field is divided into its four main problems: Determination of approximate trajectories, determination of corrections, projectile stability, and correlation between theoretical and experimental data. Ballistic aerodynamics, projectile drag in particular, is discussed.

Paper gives some rules of thumb for projectile retardation, etc. It also contains some historical notes and a bibliography of about 40 references, about half of which are French. Reviewer believes that the paper fulfills its objective: To provide orientation for those not too familiar with the field of ballistics.

Tage A. Mortensen, USA

2960. **Robertson, A. J. B., The thermal initiation of explosion in liquid explosives,** Third Symp. Combust. Flame Expl. Phenom.; Baltimore, Md., Williams & Wilkins, 545–551, 1949. $13.50.

"In an exothermic decomposition, a thermal explosion occurs when the rate of heat production becomes and remains greater than the rate of heat removal." Author develops simple theory on these lines, which explains nicely his experiments on three well-known organic explosives when account is taken of the increased heat loss in forced convection in the molten explosive, caused by the gas bubbles produced. Theory shows importance of surface/volume ratio of sample and ambient pressure. There is no induction period, and the transition to explosion is gradual.

On the other hand, potassium picrate explodes abruptly and violently, even in microgram samples. Explosion is preceded by a very variable induction period. Garner and Gomm's suggestion, that in such cases initiation is due to a local concentration of energy by statistical fluctuations, must be modified, since some period of preliminary reaction appears necessary.

Nitroglycerine can exhibit either kind of behavior.

H. H. M. Pike, England

Soil Mechanics, Seepage

(See also Rev. 2782)

2961. **Meyerhof, G. G., Building on fill with special reference to the settlement of a large factory,** *Struct. Engr.* **29,** 2, 46–57, Feb. 1951.

Author reports study of badly damaged single-story factory building constructed on 20-year-old industrial waste fill 5 ft to 30 ft in depth. Floor slab on fill has settled a maximum of 16 in., while walls on piles into London brown clay show settlements from 4 to 12 in. An interesting phenomenon observed is that fill consolidation due to floor load has produced negative friction on piles, thus exceeding pile-bearing capacity in the underlying London clay.

Author reviews general problem of constructing on waste fills both compacted and noncompacted, and concludes with a good summary of structural considerations to be used in design of buildings on fills where large settlements may be expected.

Philip P. Brown, USA

2962. **Klute, A., A numerical method for solving the flow equation for water in unsaturated materials,** *Soil Sci.* **73,** 2, 105–116, Feb. 1952.

The flow equation is derived by combining the equation of continuity with Darcy's law. An iterative process solution of the derived equation is used to obtain moisture-content distributions at various values of time in unsaturated semi-infinite horizontal porous media. Examples of the method of solution and of the moisture distribution obtained are presented for the cases of two sands and one clay. Both absorption and desorption are considered. No data are presented to substantiate the calculated moisture distribution, and no effects of temperature change or variation are considered. Donald M. Vestal, Jr., USA

2963. **Williams, T. E. H., Soil failure during the overturning of piles,** *Engineering* **173,** 4488, 134–136, Feb. 1952.

Tests using model piles in stratified cohesionless soils examined: "(1) The determination of the position of the center of rotation when the maximum overturning moment was effective. (2) The development of a method for determining the accurate form of the displaced body of sand. (3) The derivation of a formula for the maximum resistance to overturning without the introduction of coefficients." Soil was solidified and sections were sawed after testing.

"The phenomena noted during this series showed that overturning of piles takes place in three stages. First, slight rotation occurs about a point below mid-penetration depth, when a localized disturbance of the sand is observed at the foot of the pile. The pile then produces a heaving of the surface material on one side by 'punching' its way through the sand. On the opposite side, a body of sand of regular pattern is gradually mobilized and ultimately displaced. The maximum resistance to overturning is effective at the instant when the body of sand is fully developed; the center of rotation is at surface level when this occurs. Finally comes breakdown of the displaced sand body and collapse of the pile."

Soil slip surface is roughly conical and of fixed proportions. Formulas developed, giving overturning moment as function of weight of displaced wedge and friction on its conical sliding surface, give results 20% low. C. Martin Duke, USA

2964. **Touloukian, Y. S., Bottorf, J. D., and Harsen, T., Heat transfer and temperature distribution in soils for transient heat flow due to cylindrical sources and sinks,** "Frost action in soils," Symp., Nat. Res. Counc. Highway Res. Bd., spec. Rep. no. 2, 147–160, 1952. $3.75.

Authors present a brief outline of existing methods for solving the equation of heat conduction for cylindrical heat sources. These methods are: (1) Mathematical integration for the appropriate boundary conditions. (2) Numerical integration. (3) Solving by means of an electrical analogy. An example with one source is treated by all three methods; an example with 4 sources by method (2) only. In the former case, methods (1) and (3) show good agreement, while method (2) yields different temperature values near the tube.

Reviewer believes that the way in which authors treat the cylindrical problem by an electrical analogy for a one-dimensional problem is not wholly justified; the result will depend on the dimensions of the regions chosen. The numerical values of the thermal properties of soil in the examples are, in reviewer's opinion, rather different from those usually occurring in nature.

D. A. de Vries, Holland

2965. **Henkel, D. J., and Gilbert, G. D., The effect of the rubber membrane on the measured triaxial compression strength of clay samples,** *Géotechnique, Lond.* **3,** 1, 20–29, Mar. 1952.

Paper presents the results of tests to determine the effect on soil shear strength of the rubber membrane used in the undrained triaxial compression test. Correction values are given to be applied to the shear strength, and approximate theoretical considerations are developed. The effect of the rubber membrane was found to be small, and it is suggested that corrections be made only for tests on soft soils where the effective stresses are small. Paper is an excellent presentation of the effect of the rubber membrane under conditions of no volume change. Re-

viewer believes that the rubber-membrane effect under conditions of sample volume change, particularly with bulge type of shear failure, may be considerably different from that developed by the authors. Woodland G. Shockley, USA

Micromeritics

(See also Rev. 2866)

2966. **Tarján, G., Contribution to kinematics of the cyclone and cyclone washers** (in German), *Acta Techn. Hung., Budapest* 1, 1, 22–32, 1950.

A discussion of the velocity and the path of a fluid in a cyclone and of the forces acting on suspended particles. Discussion of Driessen's method of coal washing.

H. C. Brinkman, Indonesia

Geophysics, Meteorology, Oceanography

(See also Rev. 2777)

2967. **Hollmann, G., On the motion of isolated masses of cold air and their effect upon the weather** (in German), *Z. Meteor.* 6, 1, 8–15, Jan. 1952.

Author attempts to develop theoretical equations for the effects of Kaltlufttropfen, which are literally "drops of cold air." The proper translation and interpretation of this term are important because the author says that he knows of no attempt at a theoretical handling of these effects. An alternative term suggested by author is "islands of cold air," but the reviewer prefers "isolated masses of cold air," at least in English. The air masses considered in this article differ from the cold air domes considered by Rossby [AMR **3**, Rev. 1807] in the fact that Rossby's have vortical motion, but a number of the conclusions drawn by Rossby seem to apply to Hollmann's rather simplified picture. This article is to be followed by one on the same subject which will include a numerical example. W. C. Johnson, Jr., USA

2968. **Mason, M. A., Surface water wave theories,** *Proc. Amer. Soc. civ. Engrs.* **78,** Separ. no. 120, 29 pp., Mar. 1952.

Author discusses the characteristics of oscillatory surface waves and summarizes the development of pertinent theory. The more important equations that characterize wave formation and movement are presented.

The method by which waves are believed to be generated is described, and a theory of the growth of waves is formulated. Several charts provide convenient means of determining wave characteristics and wave effects from a knowledge of the limiting factors. Other subjects, including wave refraction, diffraction, and reflection, are also treated briefly.

Several formulas are available for determining the action of waves on structures. Although these formulas are not perfect, they offer convenient design criteria when used intelligently and carefully.

Paper reviews available knowledge on transportation of beach and bottom material and recommends likely fields of future research. A brief summary of the use of models in the study of wave problems is also included.

From author's summary by Walter H. Munk, USA

2969. **van Mieghem, J., Motion of atmospheric vortexes** (in French), *Tellus* **3,** 2, 75–77, May 1951.

Using a procedure similar to the transformation of equation of motion into the impulse form, author derives an expression for acceleration in a system of general curvilinear coordinates. This expression is multiplied with an arbitrary scalar α, integrated over an arbitrary volume and simplified by the use of Gauss' theorem. If the volume is chosen such that inside the volume α does not change its sign, and on its boundary either α or the velocity component normal to the boundary vanishes, the mean value of the acceleration can be computed under the assumption that the local changes of the density, α, and the acceleration can be neglected. The mean acceleration is then given by the ratio of a volume integral containing the individual change of α and of the mean value of α in the volume under consideration.

The theorem is then used for the special case when α is identified with the vertical component of relative vorticity, and its individual change is computed from Rossby's simplified vorticity equation. A simple expression for the acceleration is then obtained and used for the discussion of motion of cyclonic or anticyclonic vortexes. For a nondivergent flow, this expression reduces to formula derived by Rossby [AMR **3,** Rev. 1807]. If the flow is decomposed into a stationary zonal current and its perturbation, a similar expression for the acceleration can be derived, leading for a particular case to a formula given by Kuo [AMR **4,** Rev. 1402]. Z. Sekera, USA

2970. **Fujiwhara, S., Syono, S., Takayama, T., Yajima, S. Tamano, M., and Miyabe, N., Quantitative investigation on Okado's law in the behaviour of two vortices,** *Geophys. Mag., Tokyo* **22,** 4, 311–322, Aug. 1951.

Okado's law, apparently formulated from observing weather maps, is: A large vortex attracts and absorbs small vortexes of same sign and repels small vortexes of opposite sign. Law is verified by experiment in a tank (performed in 1925–1926), and attraction of the vortexes (in the experiment) is found proportional to cube of the distance between them.

The only physical explanation occuring to the reviewer is that a vorticity gradient exists in the motor-driven main vortex and that each small vortex (concentrated region of vorticity) moves across the gradient toward its value of vorticity in the main vortex according to the "law" of Linn and Rossby.

John C. Freeman, USA

2971. **Ogura, Y., The theory of turbulent diffusion in the atmosphere. I,** *J. meteor. Soc. Japan* **30,** 1, 23–28, Jan. 1952.

Theoretical expressions are derived for both the diffusion of small particles which follow the air motion and balloons which do not respond to smaller motions in terms of a specially defined mean eddy velocity and a Eulerian space correlation. Completed solutions are given for the case of small time and small dimensions of the spreading cloud of particles and for the case of large time and large dimensions. Certain similarities to results of other diffusion theories are noted. Lester Machta, USA

2972. **Fleagle, R. G., and Parrott, W. H., and Barad, M. L., Theory and effects of vertical temperature distribution in turbid air,** *J. Meteor.* **9,** 1, 53–60, Feb. 1952.

The temperature distribution of turbid layers above the ground is expressed as a function of the time by considering the processes of nocturnal radiation and eddy conduction. It is found to depend on the temperatures of the free air and the ground, the infrared absorptivity of the layer, and the eddy conductivity within and above the layer.

It appears that the top of the layer may cool more rapidly at night than the ground. If, in particular, the eddy conductivity is less than a certain value proportional to the infrared absorptivity, the lapse rate in or below the layer becomes unstable, while that above becomes more stable. Increased vertical mixing below and decreased vertical mixing above the top of the layer may then be expected. An atmosphere thus stratified is likely to remain so until a new factor of importance arises.

Good evidence in support of this mechanism is drawn from meteorograph and tower observations. An important application lies in the field of air pollution. In the formation of dense fog, a nocturnal surface inversion is destroyed. The decrease in stability near the surface may thus increase the danger of stack effluents being carried downward.

Walter Hitschfeld, Canada

2973. **Flohn, H., Divergence theory—cyclogenesis—anticyclogenesis** (in German), *Meteor. Rdsch.* **5**, 1/2, 8–12, Jan./Feb. 1952.

The divergence theory of cyclones (Ryd-Scherhag) is derived from a formula of Philipps on the ageostrophic component of wind and extended to the region of convergence in the rear of a frontal zone. It gives a synthesis of more ancient theories of cyclogenesis and clears the relation between cyclogenesis and anticyclogenesis. It leads to a satisfying interpretation of wave formation at cold fronts and (more rarely) at warm fronts, in relation to ageostrophic movements of air masses. An alternating relationship exists between frontal zone and surface pressure patterns. These empirical confirmed facts are established as weather rules. The accuracy of the extended divergence theory is qualitatively proved by the climatological comparison of the anomalies of the surface pressure field with the upper air pressure field (both annual mean). From author's summary

Lubrication; Bearings; Wear

(See also Rev. 2845)

2974. **Barwell, F. T., Some aspects of research on friction and wear,** *Trans. Instn. Engrs. Shipb. Scot.* **95,** part 2, 64–91, 1951–1952.

Paper is an excellent discussion of problems inherent in rubbing surfaces and current research toward understanding and solution of these frictional problems. Topics discussed include nature of surfaces, effect of surface oxides on lubrication, possible mechanisms of wear, fretting corrosion, and extreme pressure lubricants. Turning to hydrodynamic lubrication, author touches upon dynamic loading, fluid pressures between parallel surfaces, and experimental studies of high-speed bearings, including vortex flow in eccentric bearings. Lubrication of ball bearings is treated briefly and a possible explanation is put forth for the wide variation in the lives of similar ball bearings.

Charles D. Strang, Jr., USA

2975. **Heinrich, G., The hydrodynamic thrust bearing** (in German), *Maschinenbau Wärmewirtsch.* **6**, 4, 5; 57–60, 78–82; Apr., May 1951.

The design of a thrust bearing (footstep) for the end of a vertical shaft is treated analytically. The end of the shaft is plane as is also the bearing surface which is fed with lubricant through a number of vertical capillaries arranged in a circle and which dip into a reservoir. The pumping action arising from centrifugal force acting on the lubricant in the region between the capillaries and the outside edge of the shaft is equated to the pressure drop in the capillaries for both laminar and turbulent flow therein. Expressions are derived for rate of flow of lubricant, load-carrying capacity, and coefficient of friction. Second article extends the treatment to the case of a combined radial and thrust bearing on a horizontal shaft.

Reviewer considers experimental confirmation of results to be necessary, particularly as regards behavior of bearings when started from rest. F. T. Barwell, Scotland

Marine Engineering Problems

(See also Rev. 2822)

2976. **Okabe, J., and Jinnaka, T., On the waves of ships,** *Rep. Res. Inst. Fluid Engng., Kyushu Univ.* **7**, 1, 45–67, Sept. 1950.

The interaction of wave formation and boundary-layer buildup is investigated. Authors consider some well-known discrepancies in the theory of ship-wave profiles; these include the fact that the theoretical wave amplitudes are larger than the observed one, and that a weakening of the wave system at the stern together with a phase shift in the wave system is observed, the observed crests and troughs not being in the position theoretically calculated.

After discussing some previous attempts by Havelock and by Wigley to elucidate these problems, which the authors do not consider too satisfactory, an attempt is made to consider the displacement thickness of the boundary layer and the corresponding necessary corrections to the source distribution which replaces the ship form.

The method of Moriya is used to calculate the nonviscous flow, while Millikan's boundary-layer theory is used to calculate the (turbulent) boundary layer. Knowing the boundary layer, an improved source distribution for the ship form is found, and wave-surface elevations calculated.

The new theory gives the weakening of the wave system and the phase shift of the waves. However, no account is taken of the free-surface effect on the boundary layer nor of viscosity in the wave system itself, which might explain the fact that the theoretical wave amplitudes are still much too large.

Bruno Augenstein, USA

2977. **Kent, J. L., Estimation of ship's engine power from model experiment results,** *N. E. Cst. Instn. Engrs. Shipb. Trans.* **68,** part 4, 155–178, Feb. 1952.

Paper deals with the methods applied in ship-model basins to predict ship performance from model-experiment results. The possible errors in ship-trial data are discussed and may amount to 7% in many cases. Interesting data from author's large experience on effect of wind resistance on ship-trial results are presented, as well as a comparison of trial results with fine weather service performance. A new method of correcting model-experiment results is proposed, involving the construction of a torque/slip diagram for the ship from torque/slip model-experiment data, evading the procedure of using a model quasi-propulsive coefficient. Paper concludes with valuable suggestions for research needed to improve ship-model predictions. L. Troost, Holland

2978. **Silverleaf, A., Simplified launching calculations,** *Trans. Instn. Engrs. Shipb. Scot.* **95,** part 5, 317–338, 1951–1952.

Paper is divided into three sections. The first describes a method by which launching curves for any ship and any launch conditions can be rapidly derived with an accuracy approaching that obtained from a normal detailed calculation. Diagrams are given of buoyancy and moment coefficients, and a standard calculation form. The second section presents a brief analysis of the effects on stern lift conditions of variations in launching factors. The final section of the paper concerns launch stability. A direct method of calculating stability during launching is outlined, and a diagram of stability coefficients given. A typical calculation illustrates the method.

From author's summary